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FOO BIT  
OPTIMIZATION  
PROJECT

SMITH INTERNATIONAL,  
INC.

# ORCA Insert

## FEATURES

- Oblong insert bottom
- Counter Insert Rotation
- Improved Strength

Rotated and Offset Crest (.680  
crest width)

- Optimized Scraping Action
- Improved Strength

# IDEAS Results

## DUCTILE ROCK

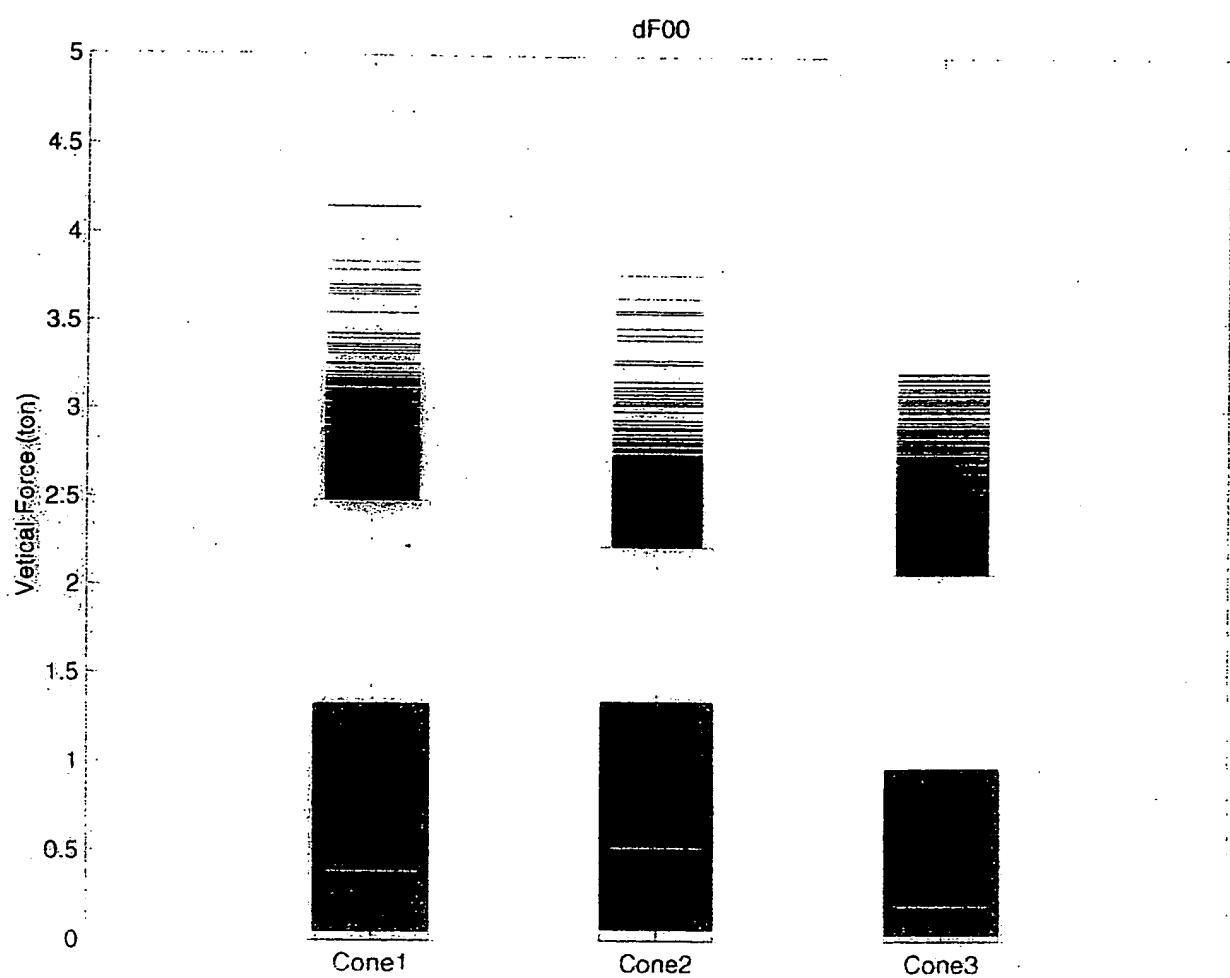
R.O.P. = 25.47 m/hr (2.6 %  
higher)

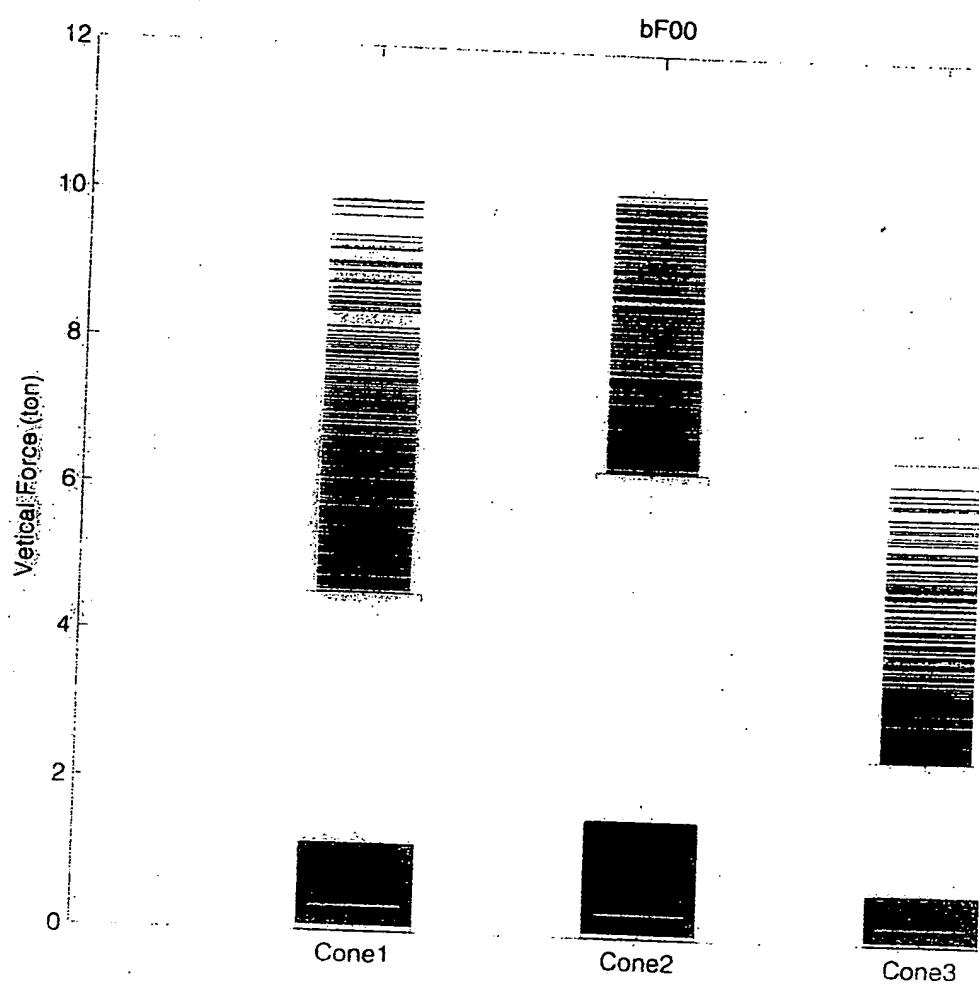
COVERAGE = 55.14 % (1.6 %  
lower)

## BRITTLE ROCK

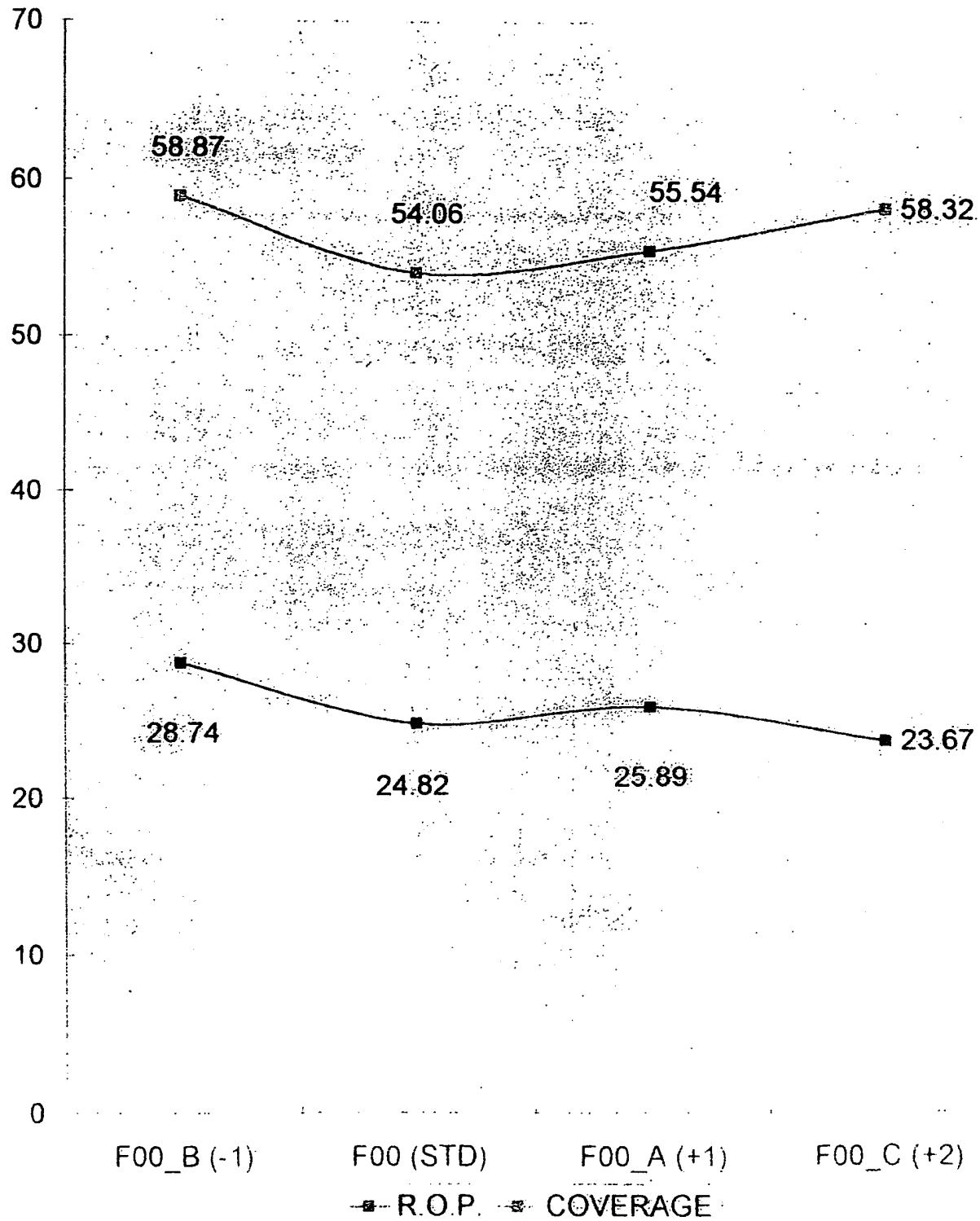
R.O.P. = 24.45 m/hr (9.3 %  
lower)

COVERAGE = 36.70 % (7.3 %  
lower)

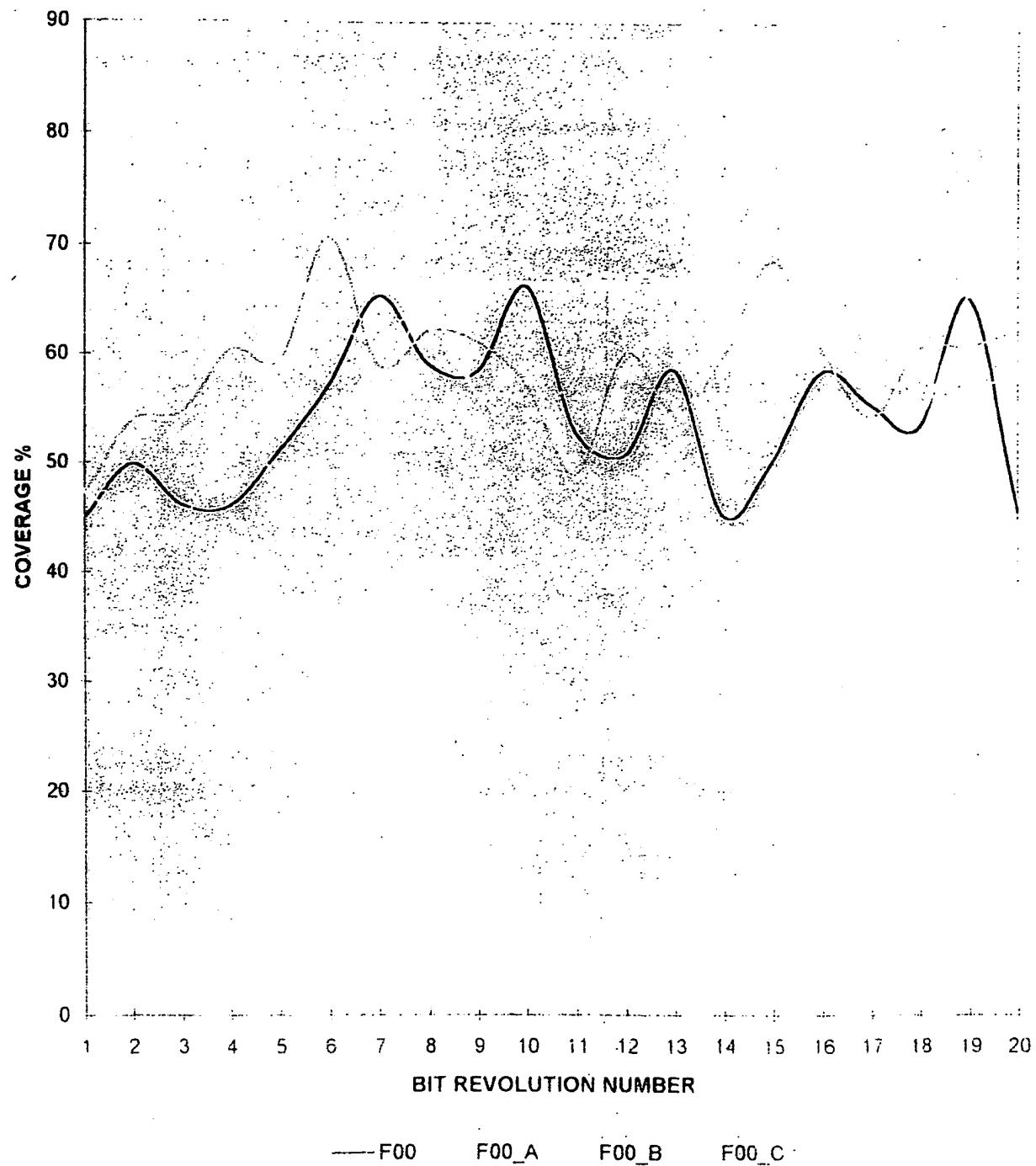




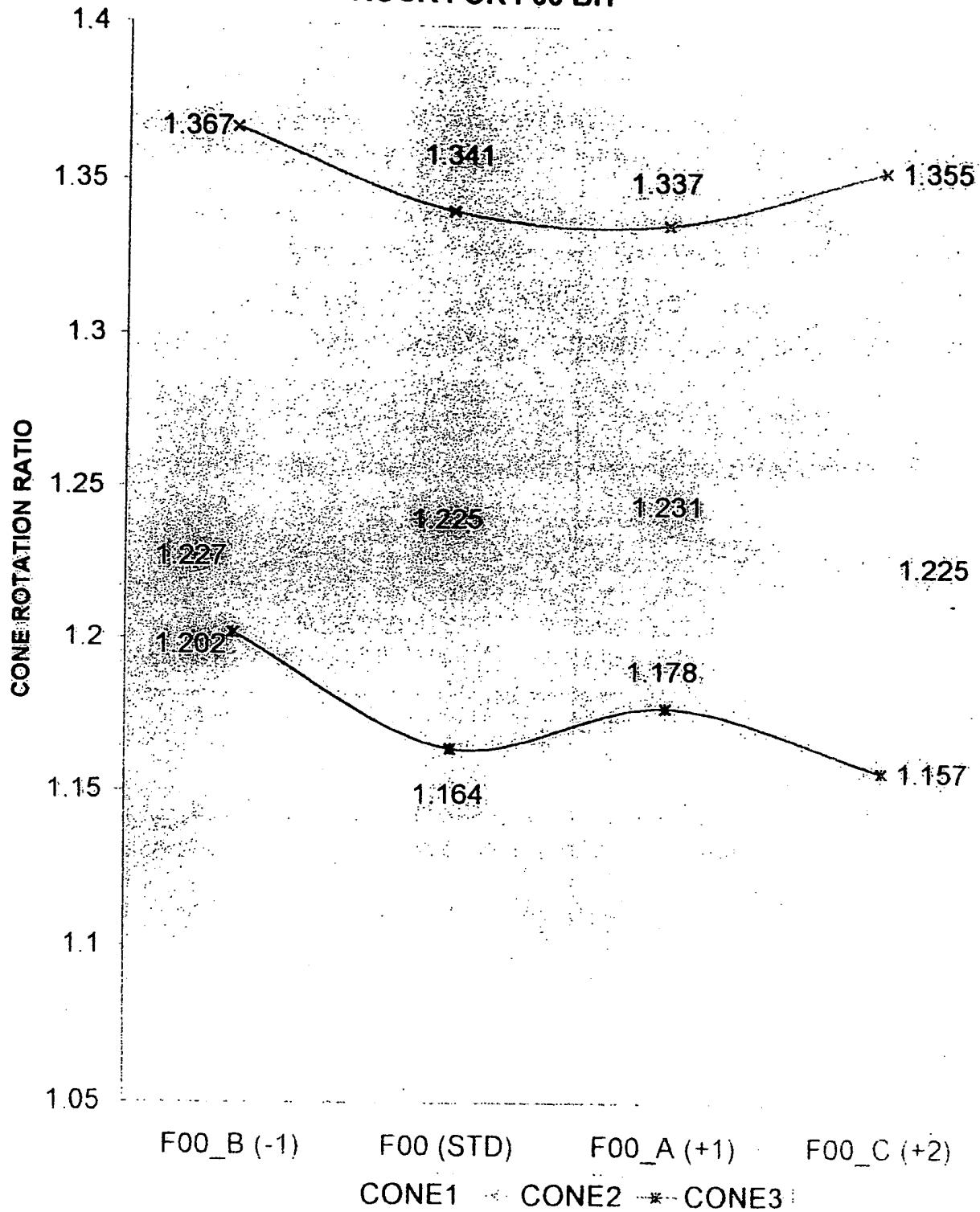
### EFFECT OF CHANGING INSERT COUNTS IN DUCTILE ROCK FOR F00 BIT



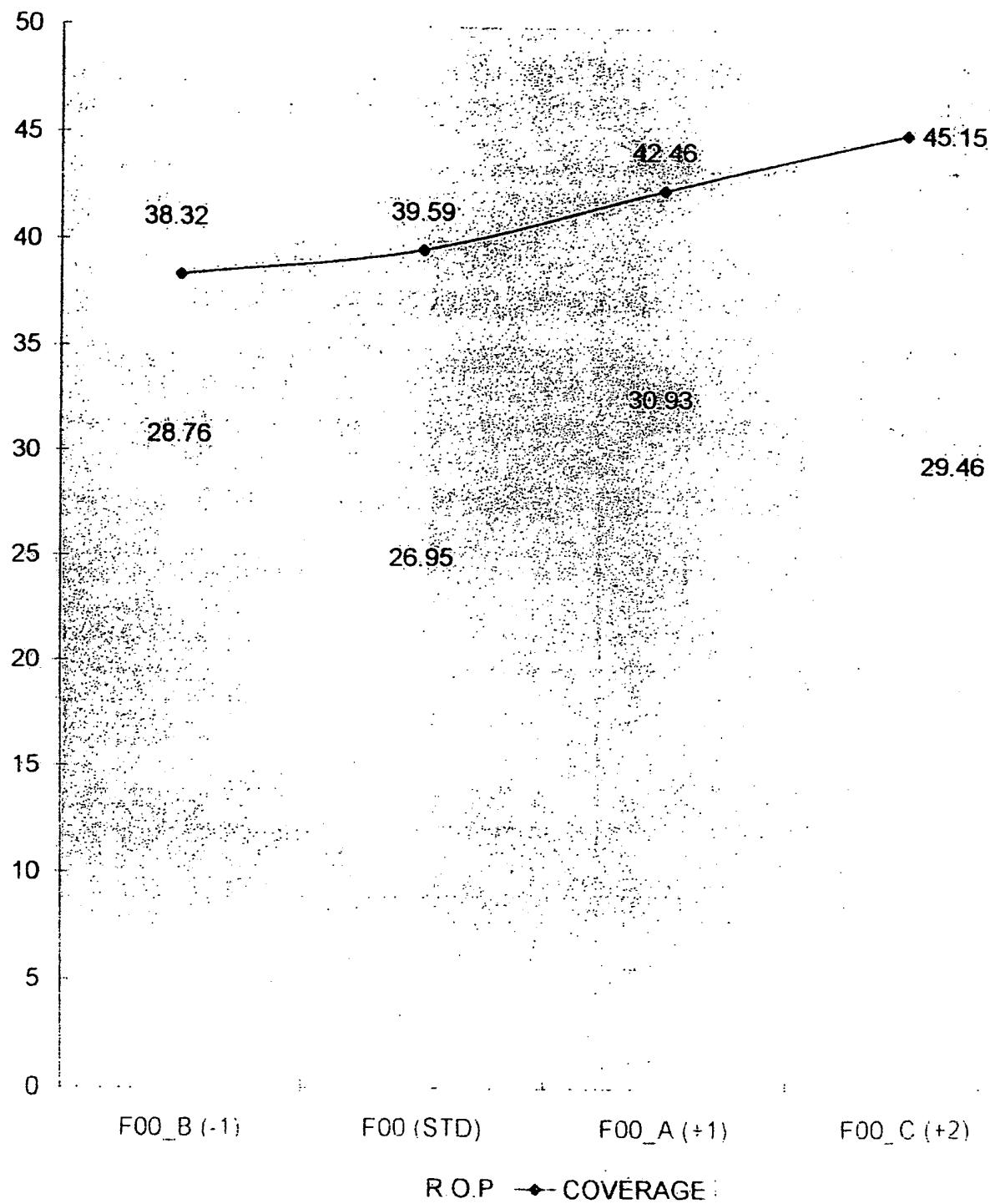
**EFFECT OF CHANGING INSERT COUNTS ON COVERAGE IN  
DUCTILE ROCK**



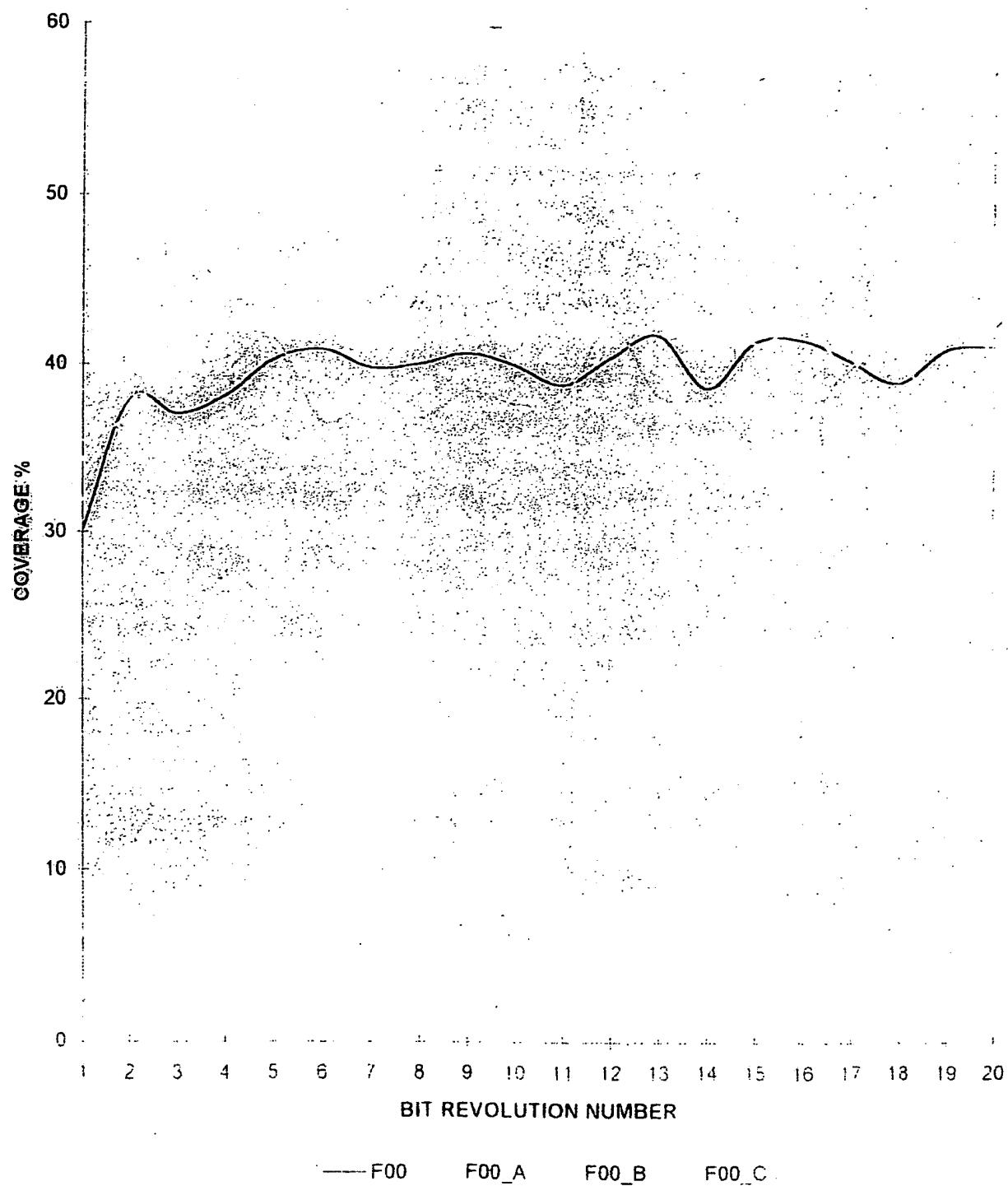
### EFFECT OF CHANGING INSERT COUNTS IN DUCTILE ROCK FOR F00 BIT



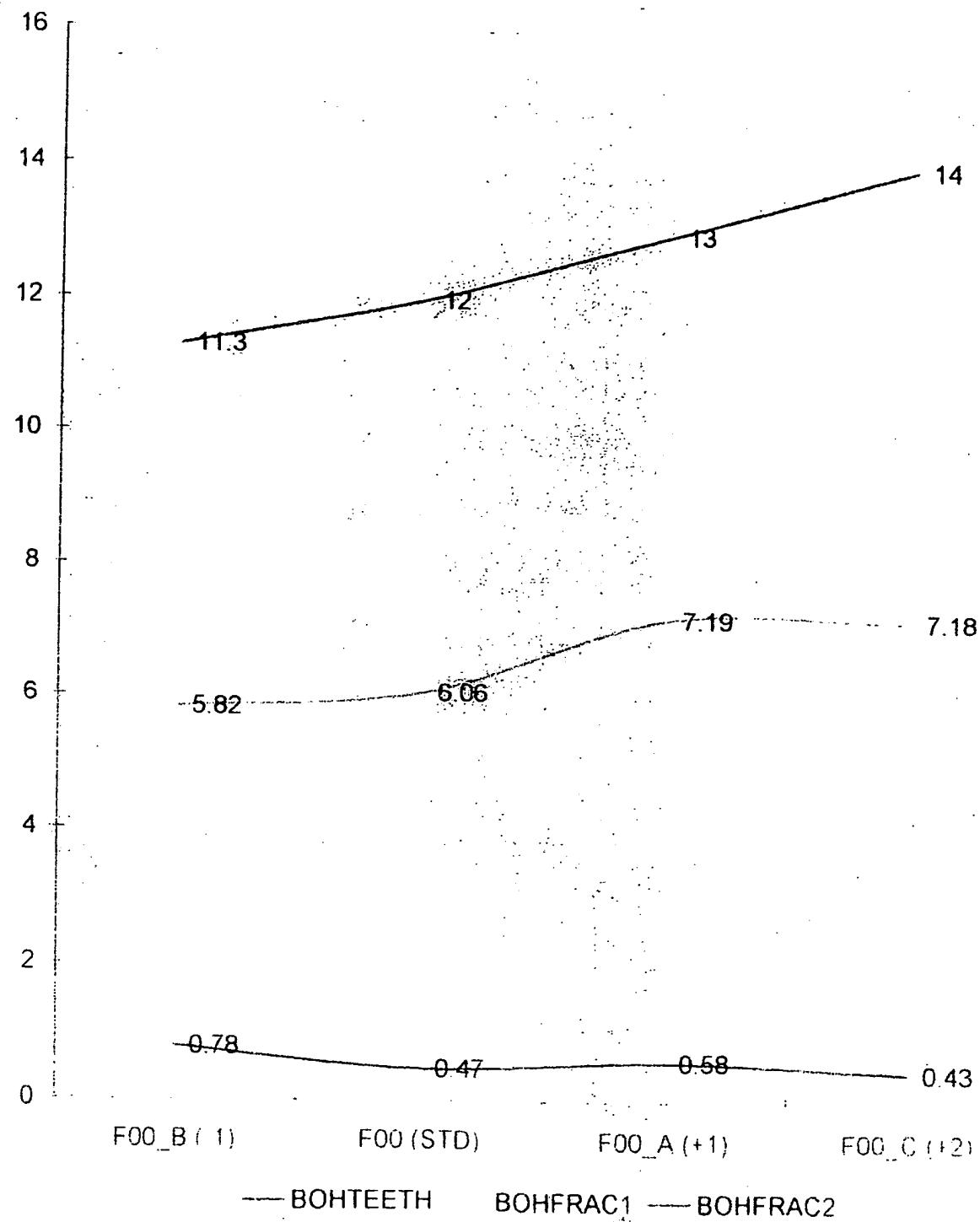
**EFFECT OF CHANGING INSERT COUNTS IN BRITTLE ROCK FOR  
F00 BIT**



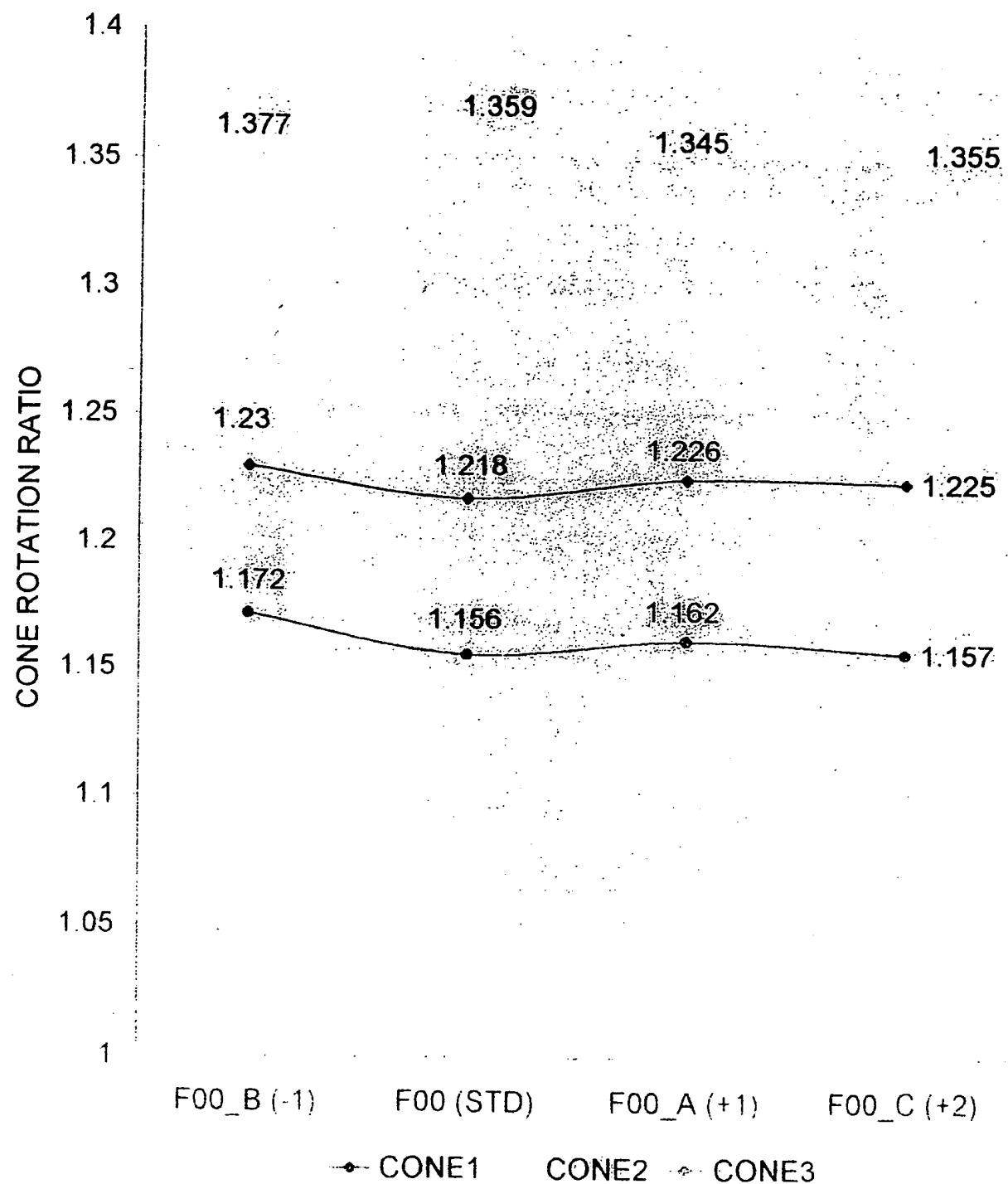
## EFFECT OF CHANGING INSERT COUNTS ON COVERAGE IN BRITTLE ROCK



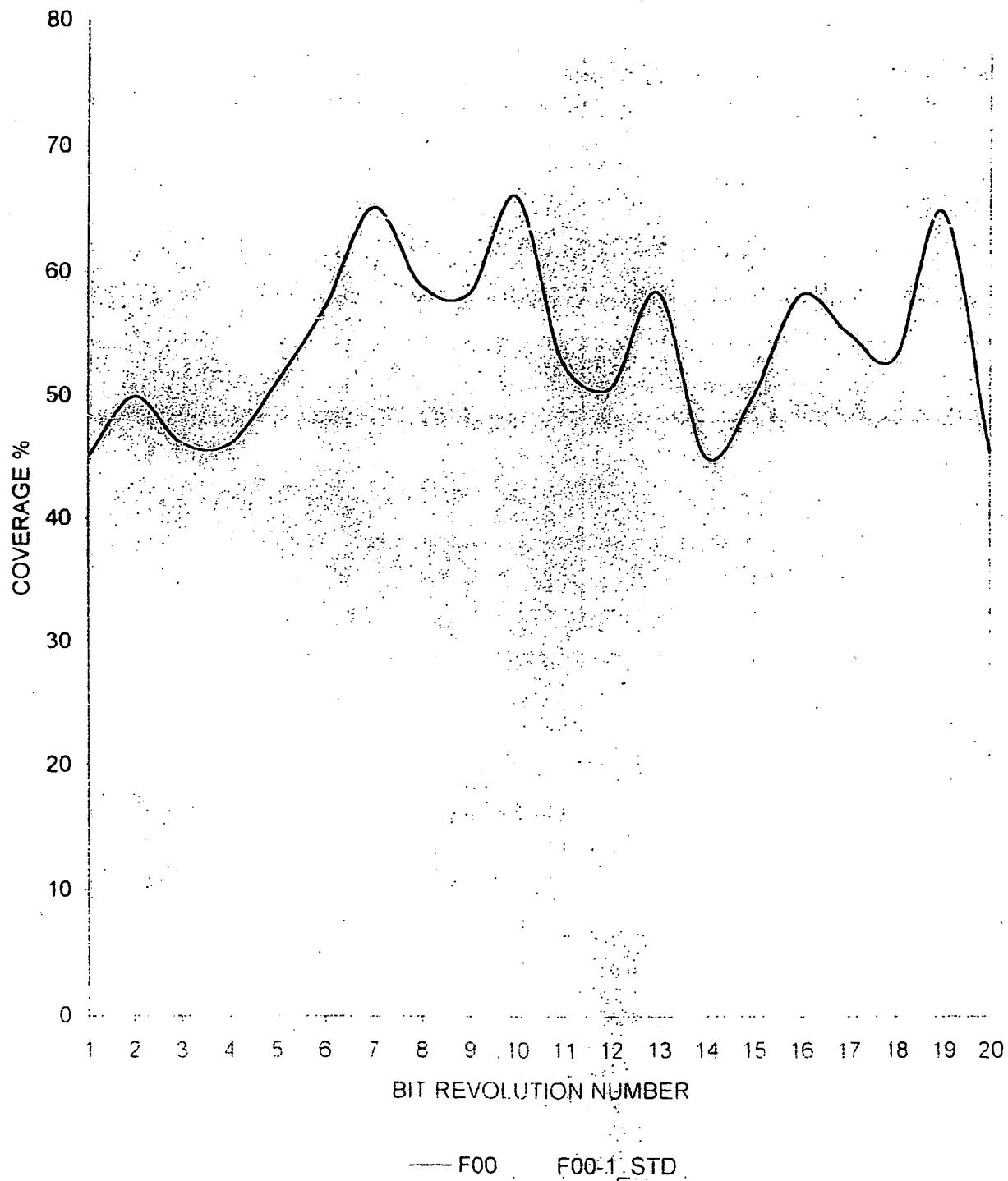
EFFECT OF CHANGING INSERT COUNTS IN BRITTLE ROCK FOR  
F00 BIT



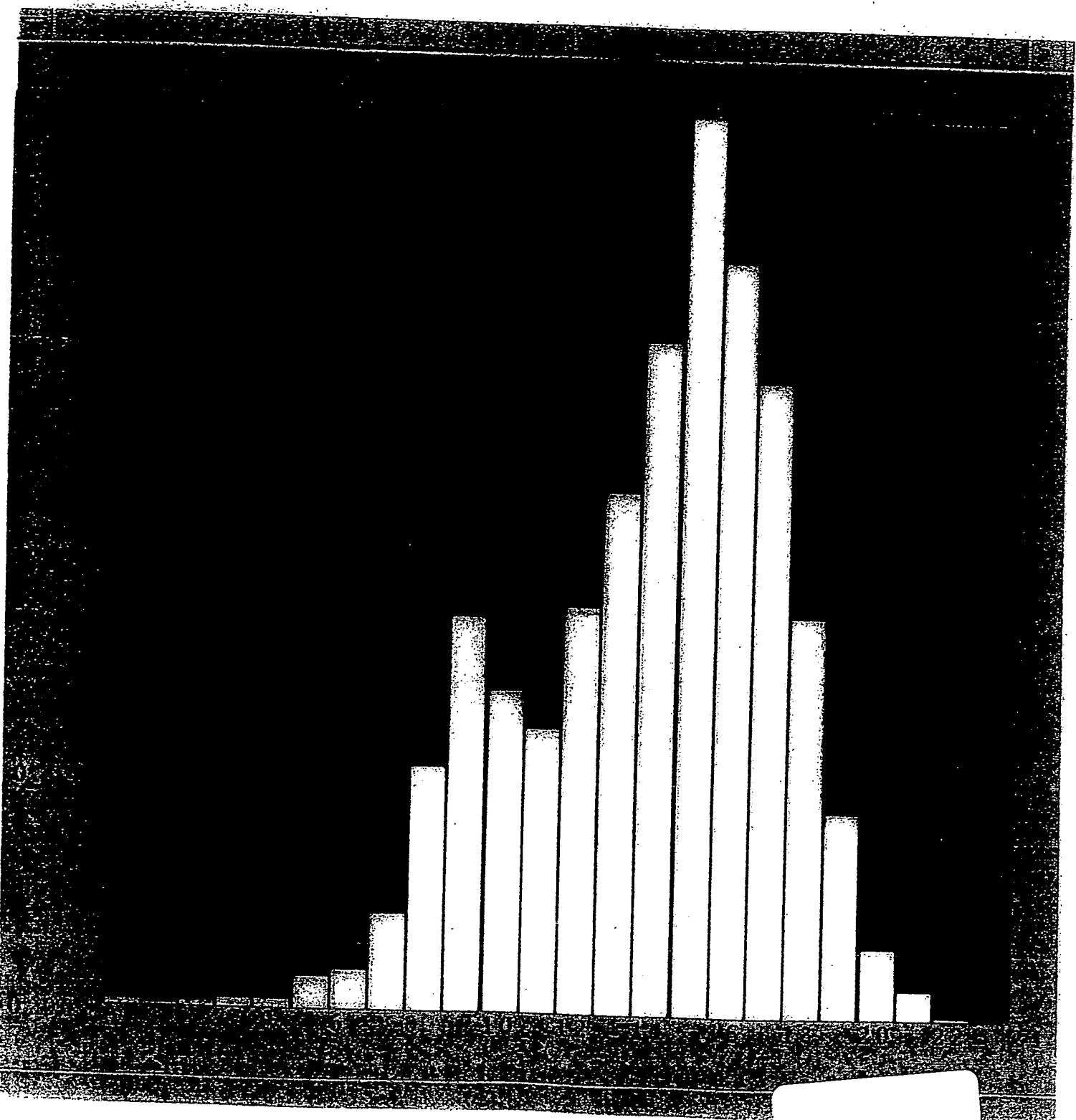
## EFFECT OF CHANGING INSERT COUNTS IN BRITTLE ROCK FOR F00 BIT



COVERAGE OF F00 BIT VERSUS F00-1 BIT (NEW C.S.) IN DUCTILE ROCK



**BIT TYPE:  
ROCK: DUCTILE**



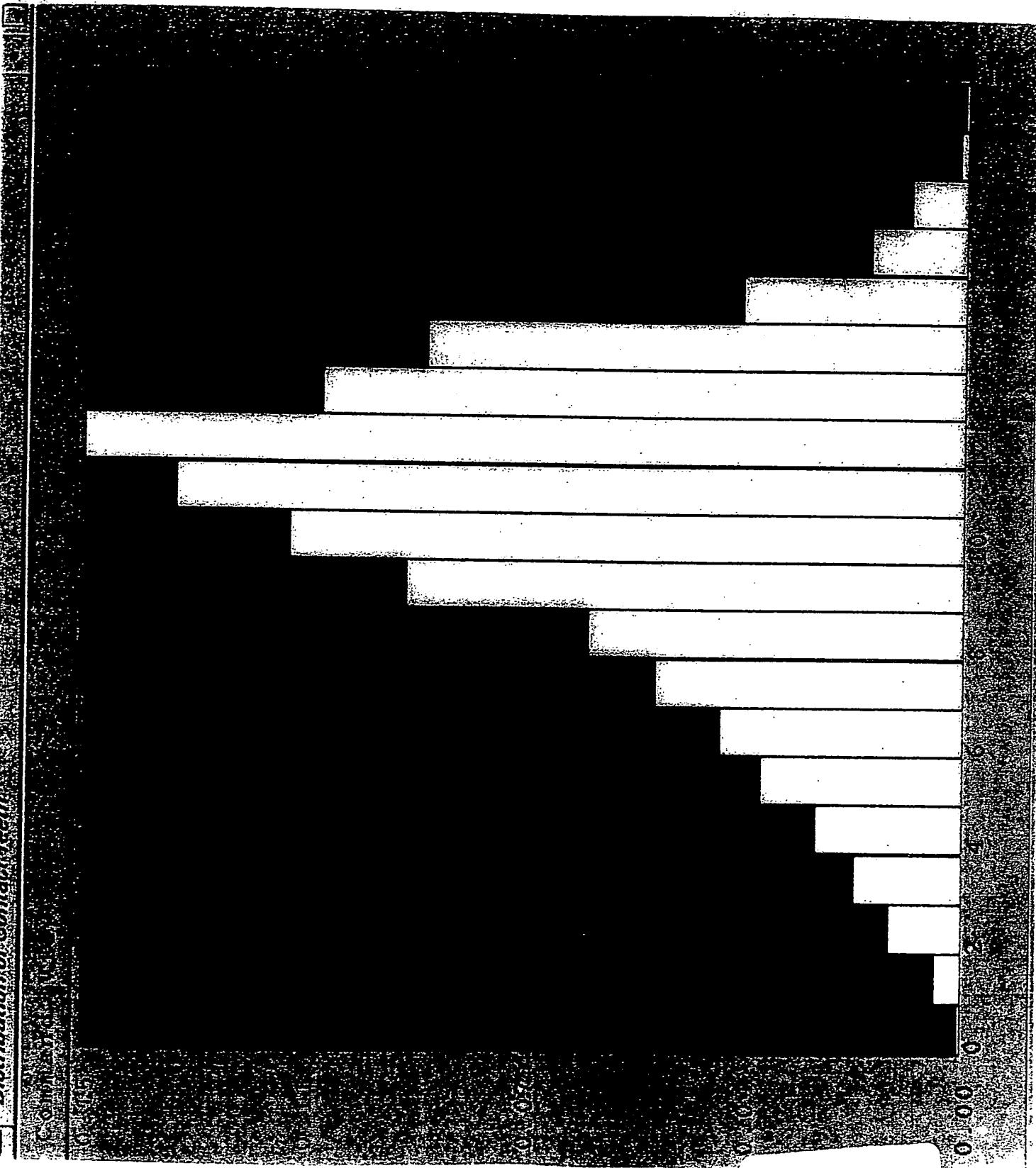
**BIT TYPE: F00-1 STD**  
**ROCK: BRITTLE**

30%

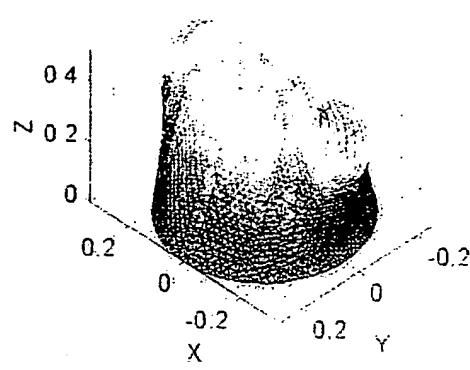
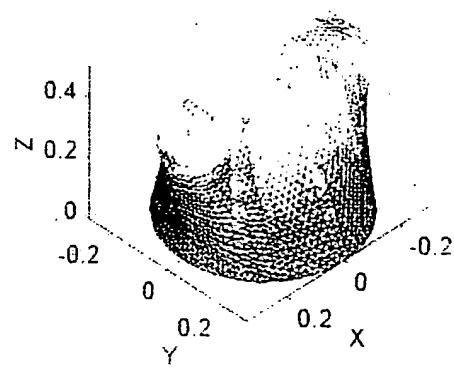
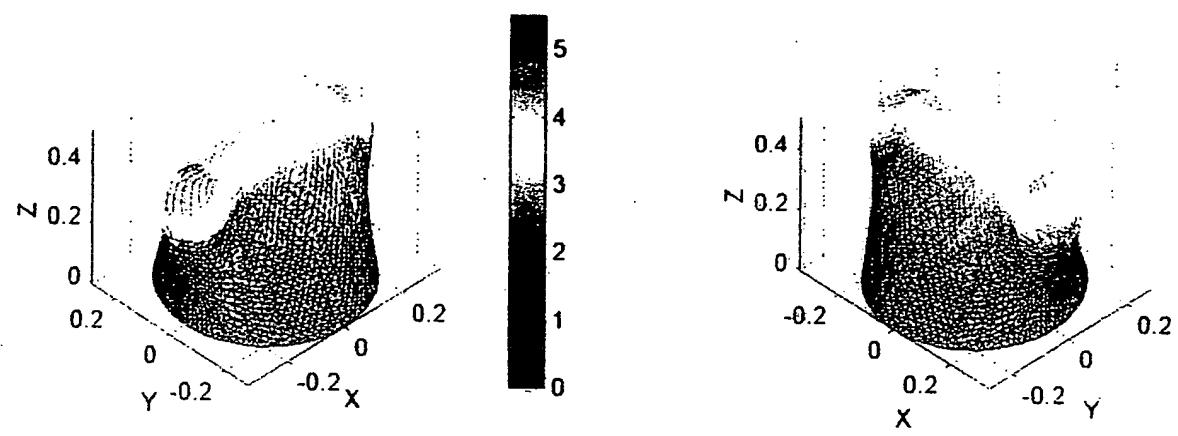
20%

10%

**BIT TYPE:**  
**ROCK: BRITTLE**

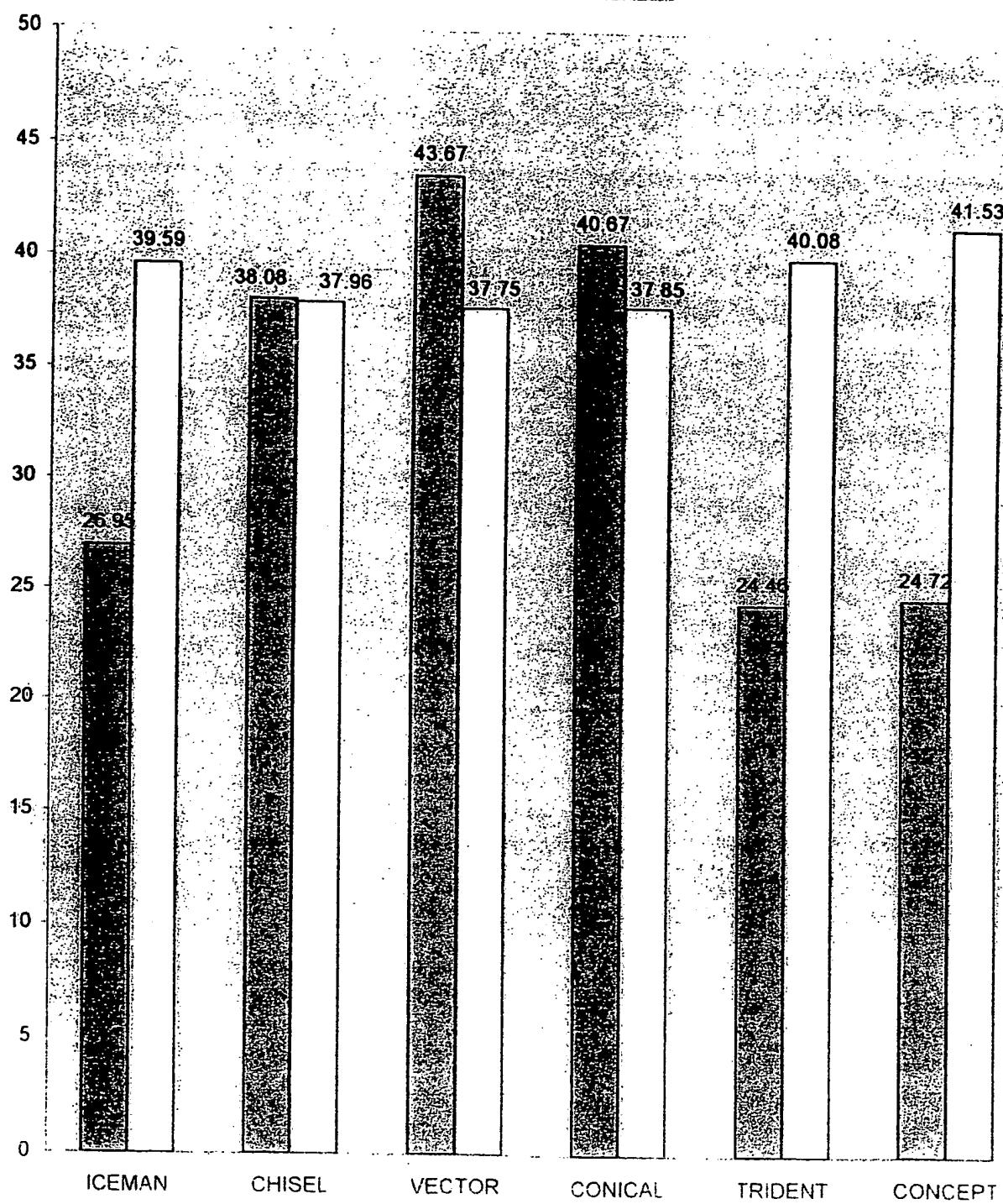


bF00-1B Cumulative Cutting (log<sub>10</sub> mm)



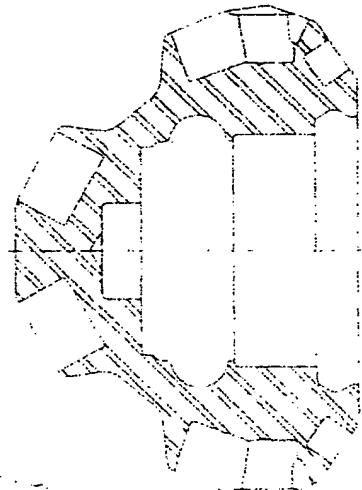
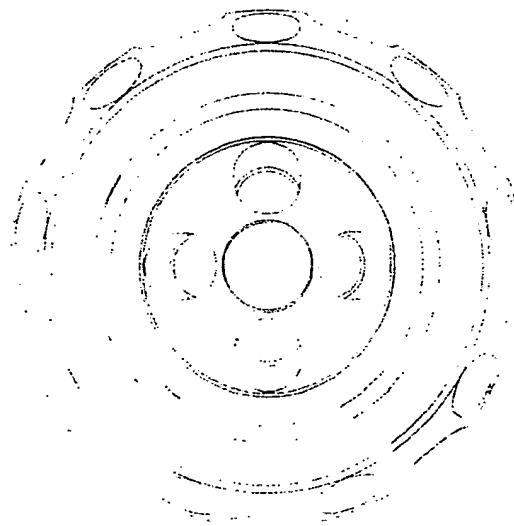
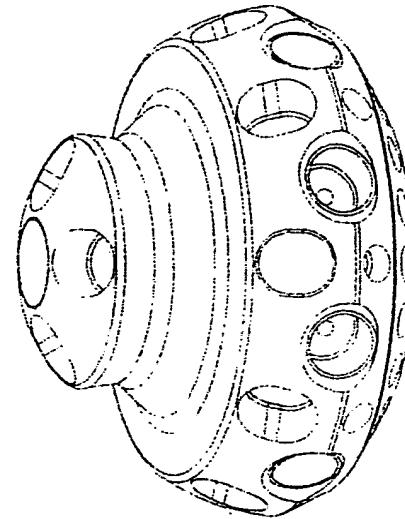
## COMPARISON OF INSERT SHAPES IN BRITTLE ROCK

R.O.P.  COVERAGE





ROW	COUNT	20. QL	30. QL	30. CL	30. CL + S
A	4	1.19			
B	9	5.32	0.60	0.72	
C	9	5.89	7.37	0.81	
D	9	9.66	7.20		
E	22	12.8			

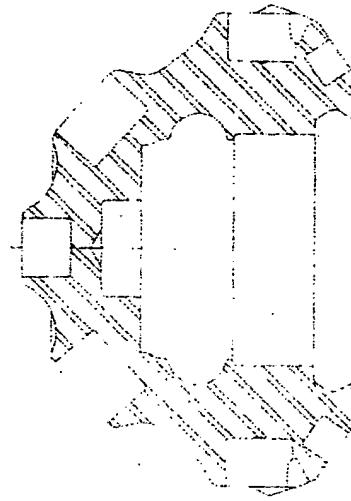
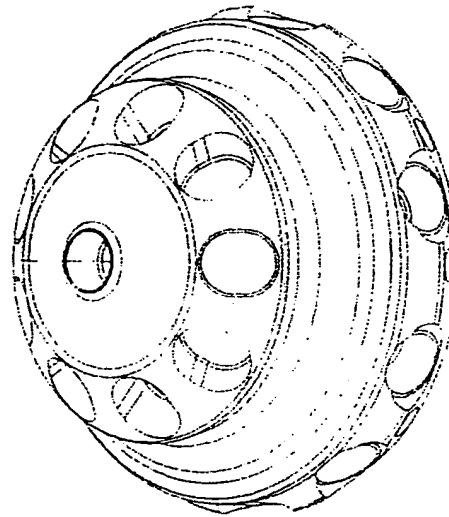


2171 (ON) A-A

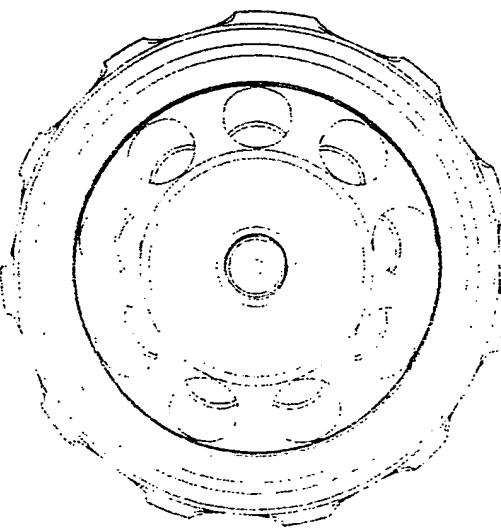
PROOF OF THE AND OPERATIONS

ART NUMBER ONE.

ROW	COUNT	20_C1	30_C1	30_C1_Sp.
A				
8	4	0.16		
	4.5	358	0.2	0.81
0	4.5	716	0.25	
1	27	128		



SECTION A-A



SMITH TOOL

CONE #3  
PROFILE AND DRAWING

Smith Tool  
Technical Drawing  
Cone #3  
Profile  
Drawing  
Date  
8 Jun 98  
Cone #3

REV	DATE	DRAWN	REV	DATE	DRAWN	REV	DATE	DRAWN
1	8 Jun 98	CONE #3						

# Insert Retention Tests

## Oblong inserts

.675 length, .5625 width, .450 grip

.675 length, .5625 width, .480 grip

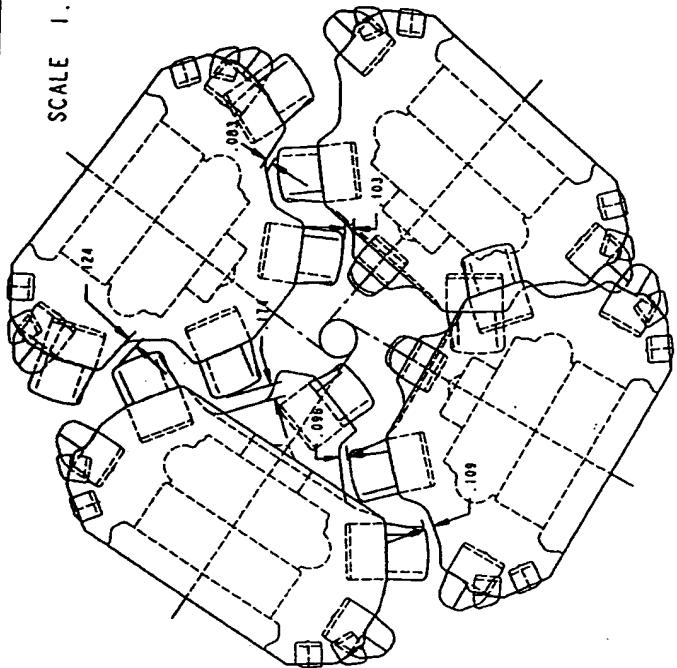
.625 length, .5625 width, .450 grip

## Standard inserts

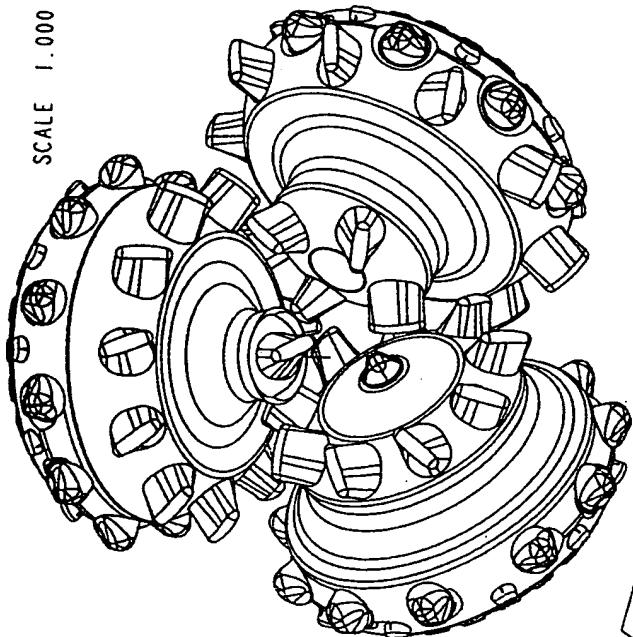
.5625 diameter, .480 grip

.5625 diameter, .450 grip

SCALE 1.000



SCALE 1.000



SCALE 3,000

Technical drawing of a mechanical part with the following dimensions and feature labels:

- SCALE 3.000
- 1.40
- 201
- 3.651
- 191
- 1.21
- 1.187
- 1.68
- 2A [4]
- 3B [9]
- 1B [11]
- 2B [9]
- 1C [11]
- 2C [9]
- 3C [11]
- 1D [11]
- 2D [9]
- 3D [11]
- 1E [22]
- 2E [22]
- 3E [22]
- Off gage distance = .038

ORCA-817							
NAME	ROW	INSERT	COUNT	PITCH	TYPE	DIAM/WD	LENGTH
CORE 1	1	ORCA1	1		ORCA	.165	.61
	2	ORCA2	1		ORCA	.165	.61
	3	ORCA3	1		ORCA	.165	.61
	4	ORCA4	1		ORCA	.165	.61
	5	ORCA5	1		ORCA	.165	.61
	6	ORCA6	1		ORCA	.165	.61
	7	ORCA7	1		ORCA	.165	.61
	8	ORCA8	1		ORCA	.165	.61
	9	ORCA9	1		ORCA	.165	.61
	10	ORCA10	1		ORCA	.165	.61
	11	ORCA11	1		ORCA	.165	.61
	12	ORCA12	1		ORCA	.165	.61
	13	ORCA13	1		ORCA	.165	.61
	14	ORCA14	1		ORCA	.165	.61
	15	ORCA15	1		ORCA	.165	.61
	16	ORCA16	1		ORCA	.165	.61
	17	ORCA17	1		ORCA	.165	.61
	18	ORCA18	1		ORCA	.165	.61
	19	ORCA19	1		ORCA	.165	.61
	20	ORCA20	1		ORCA	.165	.61
	21	ORCA21	1		ORCA	.165	.61
	22	ORCA22	1		ORCA	.165	.61
	23	ORCA23	1		ORCA	.165	.61
	24	ORCA24	1		ORCA	.165	.61
	25	ORCA25	1		ORCA	.165	.61
	26	ORCA26	1		ORCA	.165	.61
	27	ORCA27	1		ORCA	.165	.61
	28	ORCA28	1		ORCA	.165	.61
	29	ORCA29	1		ORCA	.165	.61
	30	ORCA30	1		ORCA	.165	.61
	31	ORCA31	1		ORCA	.165	.61
	32	ORCA32	1		ORCA	.165	.61
	33	ORCA33	1		ORCA	.165	.61
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	36	ORCA36	1		ORCA	.165	.61
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	42	ORCA42	1		ORCA	.165	.61
	43	ORCA43	1		ORCA	.165	.61
	44	ORCA44	1		ORCA	.165	.61
	45	ORCA45	1		ORCA	.165	.61
	46	ORCA46	1		ORCA	.165	.61
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	58	ORCA58	1		ORCA	.165	.61
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	165	ORCA165	1		ORCA	.165	.61
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	191	ORCA191	1		ORCA	.165	.61
	192	ORCA192	1		ORCA	.165	.61
	193	ORCA193	1		ORCA	.165	.61
	194	ORCA194	1		ORCA	.165	.61
	195	ORCA195	1		ORCA	.165	.61
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	202	ORCA202	1		ORCA	.165	.61
	203	ORCA203	1		ORCA	.165	.61
	204	ORCA204	1		ORCA	.165	.61
	205	ORCA205	1		ORCA	.165	.61
	206	ORCA206	1		ORCA	.165	.61
	207	ORCA207	1		ORCA	.165	.61
	208	ORCA208	1		ORCA	.165	.61
	209	ORCA209	1		ORCA	.165	.61
	210	ORCA210	1		ORCA	.1	

# SMITH TOOL

International Inc.

077 FOO BIT LAYOUT  
ORCA INSERTS

SCALE: 0.3	MODEL NAME: 10107-ORCA	SHEET: 1 OF 1
SIZE DRAWN DATE	DRAWING NO.	REV
C AS 4-Jun-98	10107-ORCA	-

# IDEAS Results

## ■ DUCTILE ROCK

R.O.P.=25.47 m/hr (2.6 %  
higher)

COVERAGE=55.14 % (1.6 %  
lower)

## BRITTLE ROCK

R.O.P.=24.45 m/hr (9.3 %  
lower)

COVERAGE=36.70 % (7.3 %  
lower)

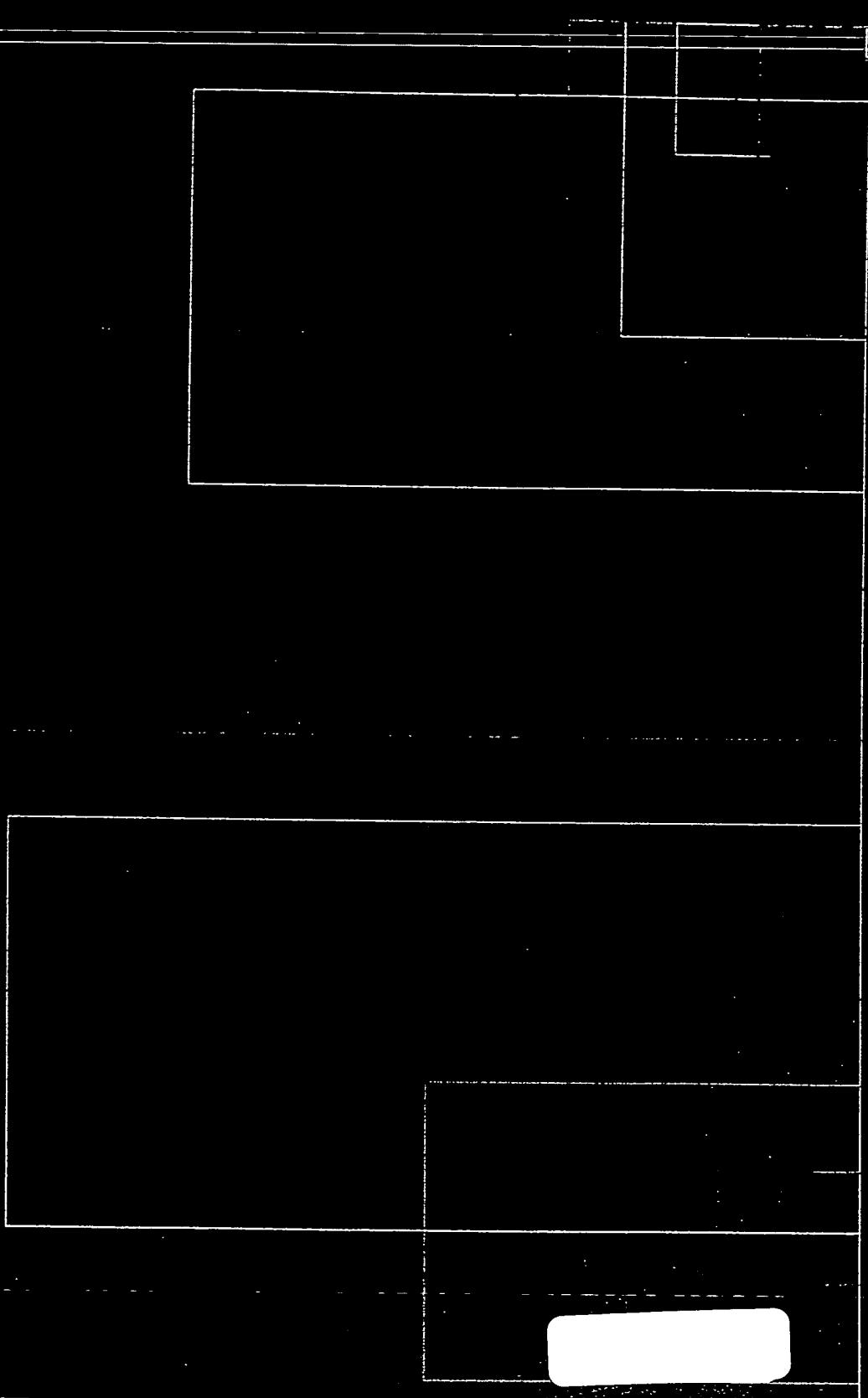
40%

30%

20%

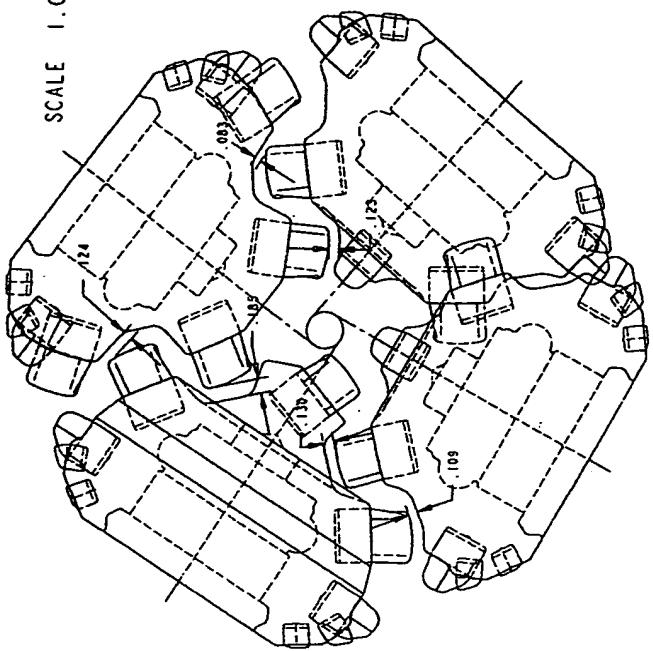
10%

0%

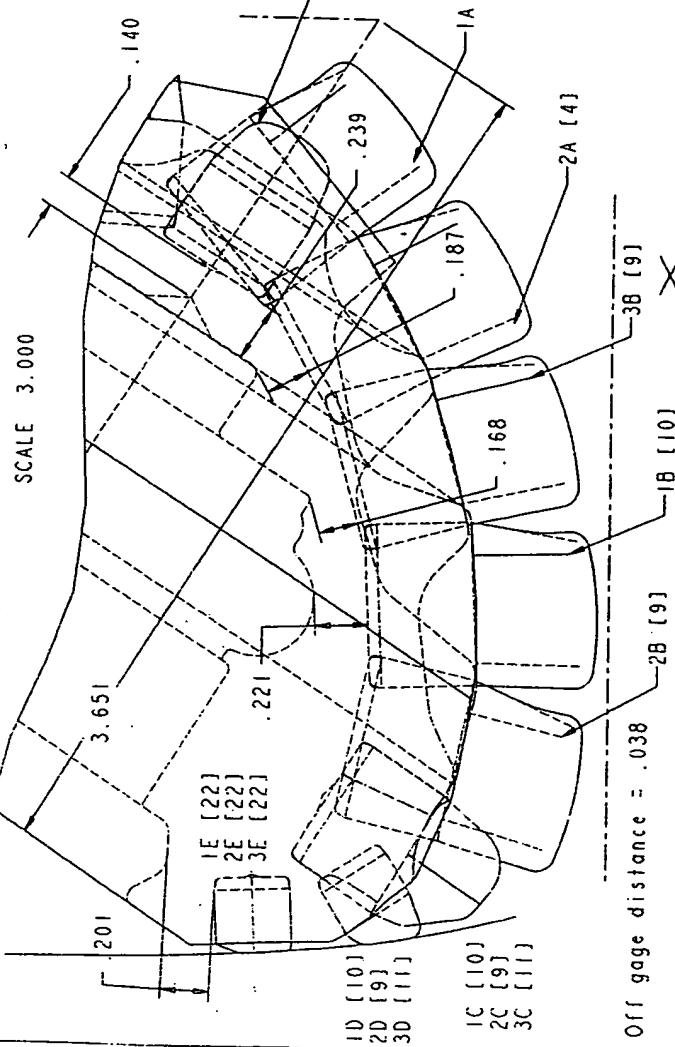
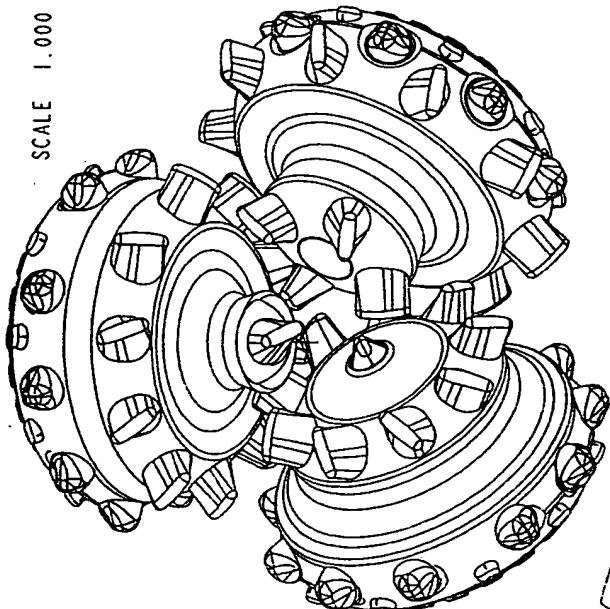




SCALE 1.000



SCALE 1.000



ORCA-BIT						
NAME	ROW	INSERT COUNT	PITCH	TYPE	DIAMOND LENGTH	BIT GRIP ORBIT
CONE1	A	ORCA1	10	ORCA	.0175	.01
	B	ORCA1	10	ORCA	.0175	.10
	C	8.6400	10	ORCA	.0175	.30
	D	8.6400	10	ORCA	.0175	.30
	E	8.6400	10	ORCA	.0175	.40
	F	8.6400	10	ORCA	.0175	.40
	G	8.6400	10	ORCA	.0175	.40
	H	8.6400	10	ORCA	.0175	.40
	I	8.6400	10	ORCA	.0175	.40
	J	8.6400	10	ORCA	.0175	.40
	K	8.6400	10	ORCA	.0175	.40
	L	8.6400	10	ORCA	.0175	.40
	M	8.6400	10	ORCA	.0175	.40
	N	8.6400	10	ORCA	.0175	.40
	O	8.6400	10	ORCA	.0175	.40
	P	8.6400	10	ORCA	.0175	.40
	Q	8.6400	10	ORCA	.0175	.40
	R	8.6400	10	ORCA	.0175	.40
	S	8.6400	10	ORCA	.0175	.40
	T	8.6400	10	ORCA	.0175	.40
	U	8.6400	10	ORCA	.0175	.40
	V	8.6400	10	ORCA	.0175	.40
	W	8.6400	10	ORCA	.0175	.40
	X	8.6400	10	ORCA	.0175	.40
	Y	8.6400	10	ORCA	.0175	.40
	Z	8.6400	10	ORCA	.0175	.40
	A1	ORCA1	1	ORCA	.0175	.10
	B1	ORCA1	1	ORCA	.0175	.30
	C1	8.6400	1	ORCA	.0175	.30
	D1	8.6400	1	ORCA	.0175	.40
	E1	8.6400	1	ORCA	.0175	.40
	F1	8.6400	1	ORCA	.0175	.40
	G1	8.6400	1	ORCA	.0175	.40
	H1	8.6400	1	ORCA	.0175	.40
	I1	8.6400	1	ORCA	.0175	.40
	J1	8.6400	1	ORCA	.0175	.40
	K1	8.6400	1	ORCA	.0175	.40
	L1	8.6400	1	ORCA	.0175	.40
	M1	8.6400	1	ORCA	.0175	.40
	N1	8.6400	1	ORCA	.0175	.40
	O1	8.6400	1	ORCA	.0175	.40
	P1	8.6400	1	ORCA	.0175	.40
	Q1	8.6400	1	ORCA	.0175	.40
	R1	8.6400	1	ORCA	.0175	.40
	S1	8.6400	1	ORCA	.0175	.40
	T1	8.6400	1	ORCA	.0175	.40
	U1	8.6400	1	ORCA	.0175	.40
	V1	8.6400	1	ORCA	.0175	.40
	W1	8.6400	1	ORCA	.0175	.40
	X1	8.6400	1	ORCA	.0175	.40
	Y1	8.6400	1	ORCA	.0175	.40
	Z1	8.6400	1	ORCA	.0175	.40
	A2	ORCA1	1	ORCA	.0175	.10
	B2	ORCA1	1	ORCA	.0175	.30
	C2	8.6400	1	ORCA	.0175	.30
	D2	8.6400	1	ORCA	.0175	.40
	E2	8.6400	1	ORCA	.0175	.40
	F2	8.6400	1	ORCA	.0175	.40
	G2	8.6400	1	ORCA	.0175	.40
	H2	8.6400	1	ORCA	.0175	.40
	I2	8.6400	1	ORCA	.0175	.40
	J2	8.6400	1	ORCA	.0175	.40
	K2	8.6400	1	ORCA	.0175	.40
	L2	8.6400	1	ORCA	.0175	.40
	M2	8.6400	1	ORCA	.0175	.40
	N2	8.6400	1	ORCA	.0175	.40
	O2	8.6400	1	ORCA	.0175	.40
	P2	8.6400	1	ORCA	.0175	.40
	Q2	8.6400	1	ORCA	.0175	.40
	R2	8.6400	1	ORCA	.0175	.40
	S2	8.6400	1	ORCA	.0175	.40
	T2	8.6400	1	ORCA	.0175	.40
	U2	8.6400	1	ORCA	.0175	.40
	V2	8.6400	1	ORCA	.0175	.40
	W2	8.6400	1	ORCA	.0175	.40
	X2	8.6400	1	ORCA	.0175	.40
	Y2	8.6400	1	ORCA	.0175	.40
	Z2	8.6400	1	ORCA	.0175	.40

**SMITH TOOL**  
Division of Smith International Inc.

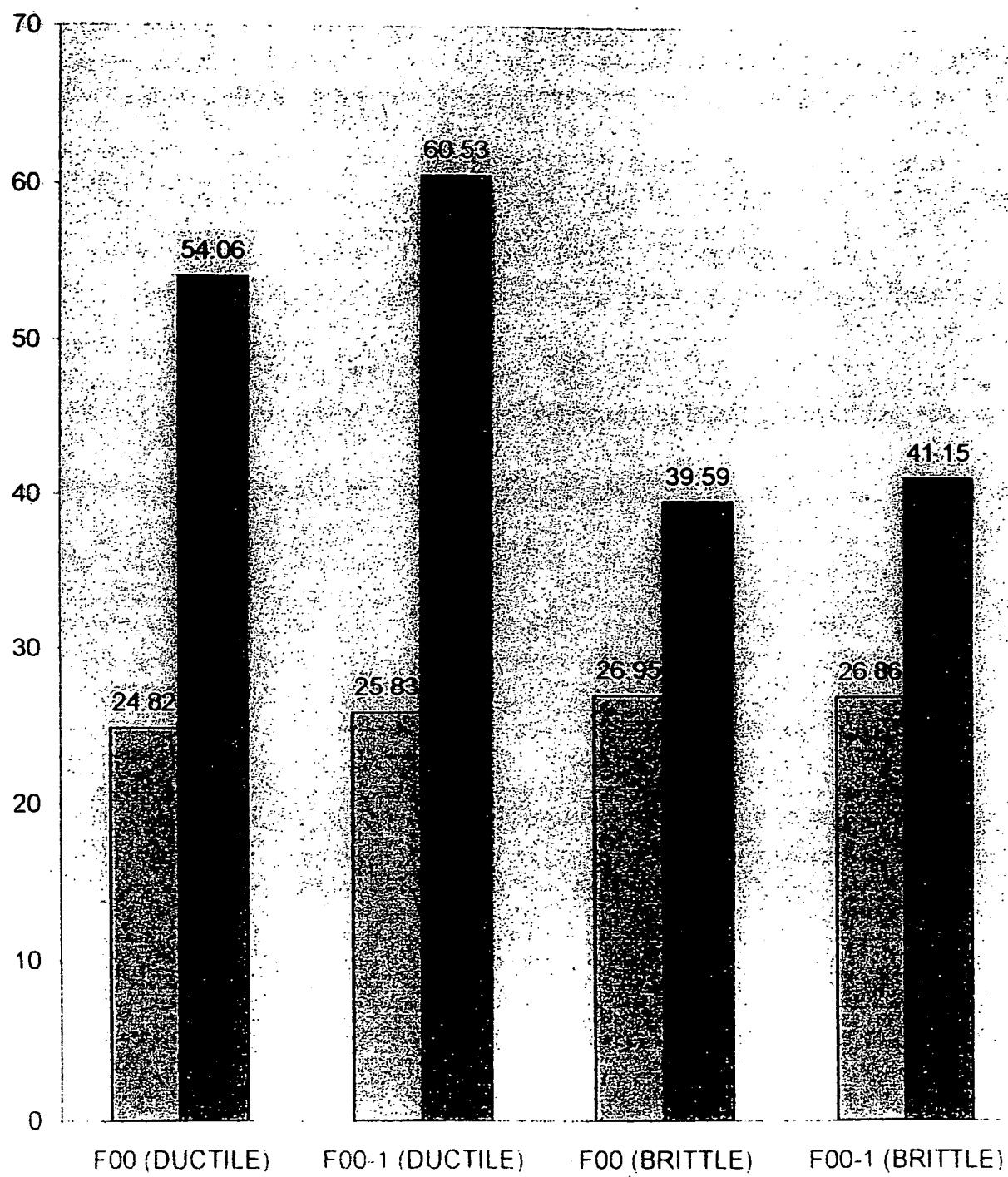
077 F00 BIT LAYOUT  
ORCA INSERTS

PART NUMBER: LT077-ORCA  
SCALE: 0.3 MODEL NAME: LT077-ORCA SHEET: 1 OF 1  
SIZE: 0.3 DRAWN DATE: 4-Jun-98 DRAWING NO. LT077-ORCA REV. C AS 3C [11]

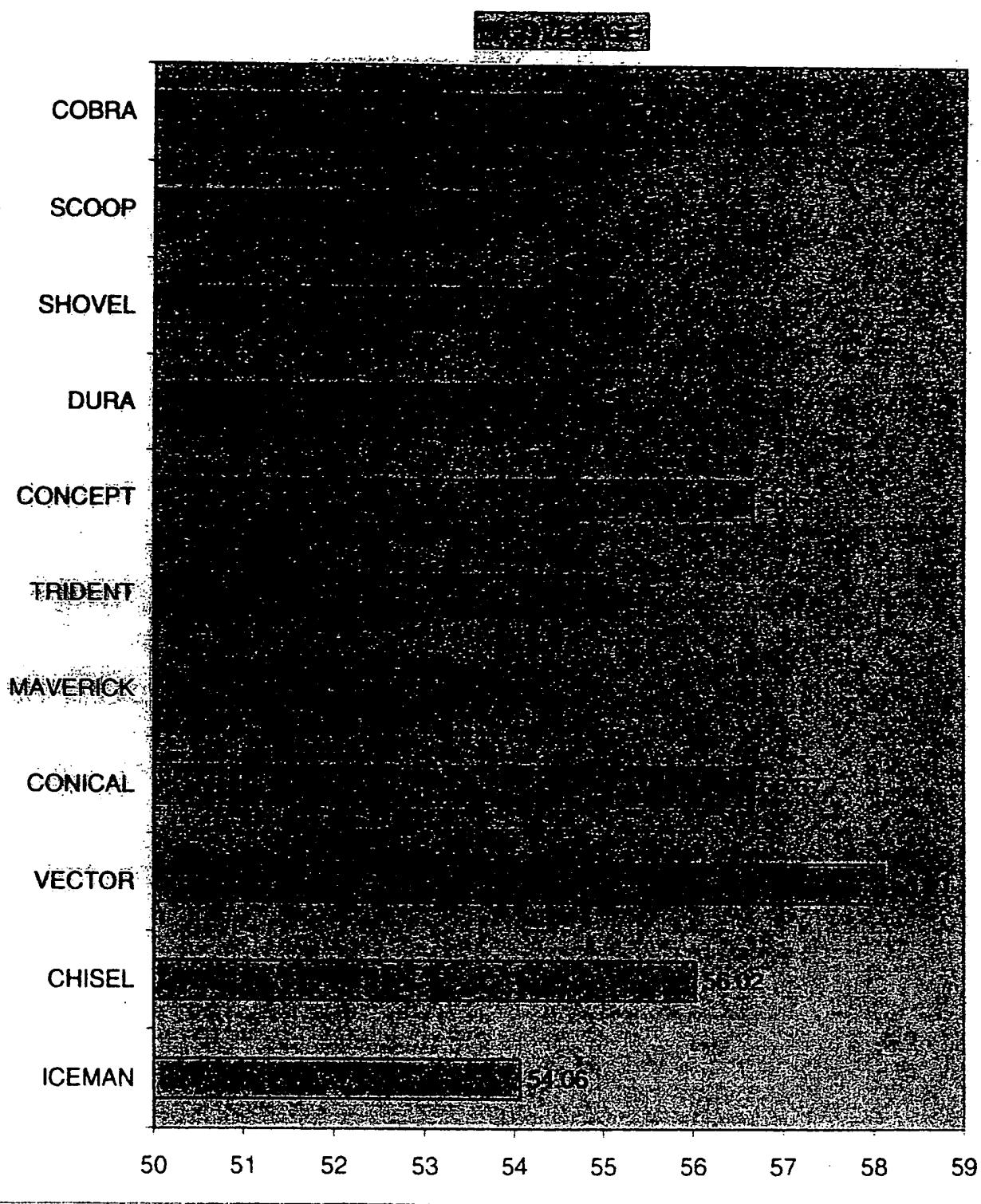
Off gage distance = .038  
2B [9] X  
1B [10] X  
1C [10] X  
2C [9] X  
3C [11] X

## COMPARISON OF CUTTING STRUCTURES

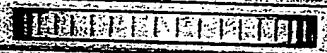
R.O.P.  COVERAGE



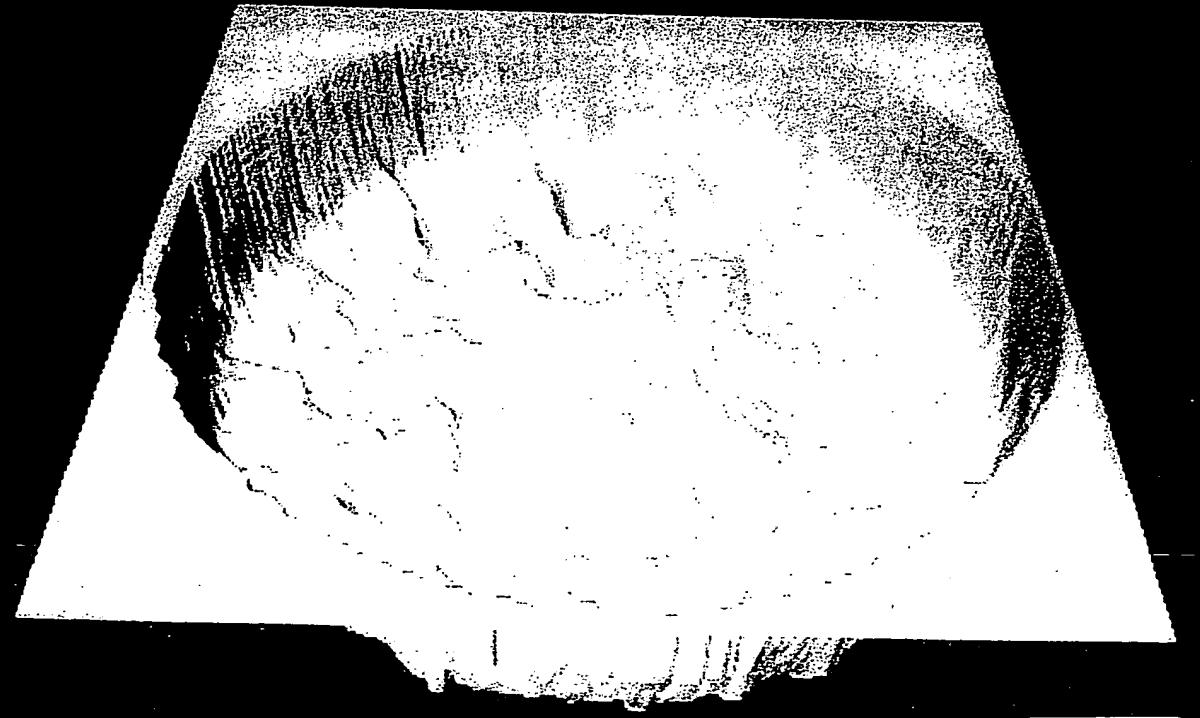
## COMPARISON OF INSERT SHAPES IN DUCTILE ROCK





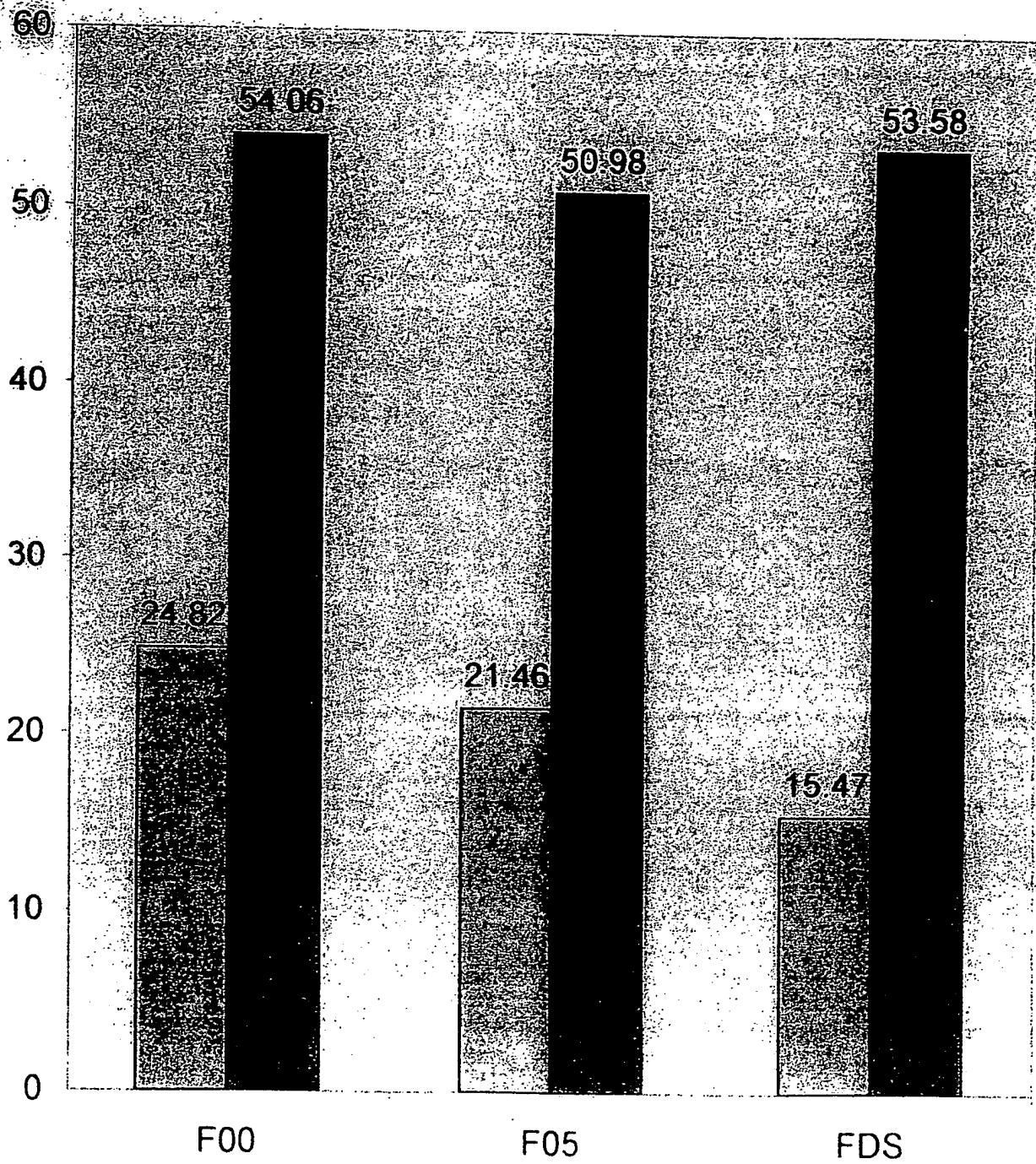
Rox Rox 

Dolly



## BENCHMARKING OF F00 BIT IN DUCTILE ROCK

R.O.P.  COVERAGE



# Attacking The Goat in Brutal Rock

## INSERT SHAPES

R.O.P. = 62% Increase  
[Vector] (Coverage being 5%  
lower)

COVERAGE = 5% Increase  
[Concept] (R.O.P. being 9%  
lower)

## ROW COUNTS

R.O.P. = 15% Increase [+1  
Insert on each row]

COVERAGE = 14% Increase  
[+2 Inserts on each row]

# Surpassing The Target In Ductile Rock

## INSERT SHAPES

R.O.P. = 12% Increase  
[Vector]

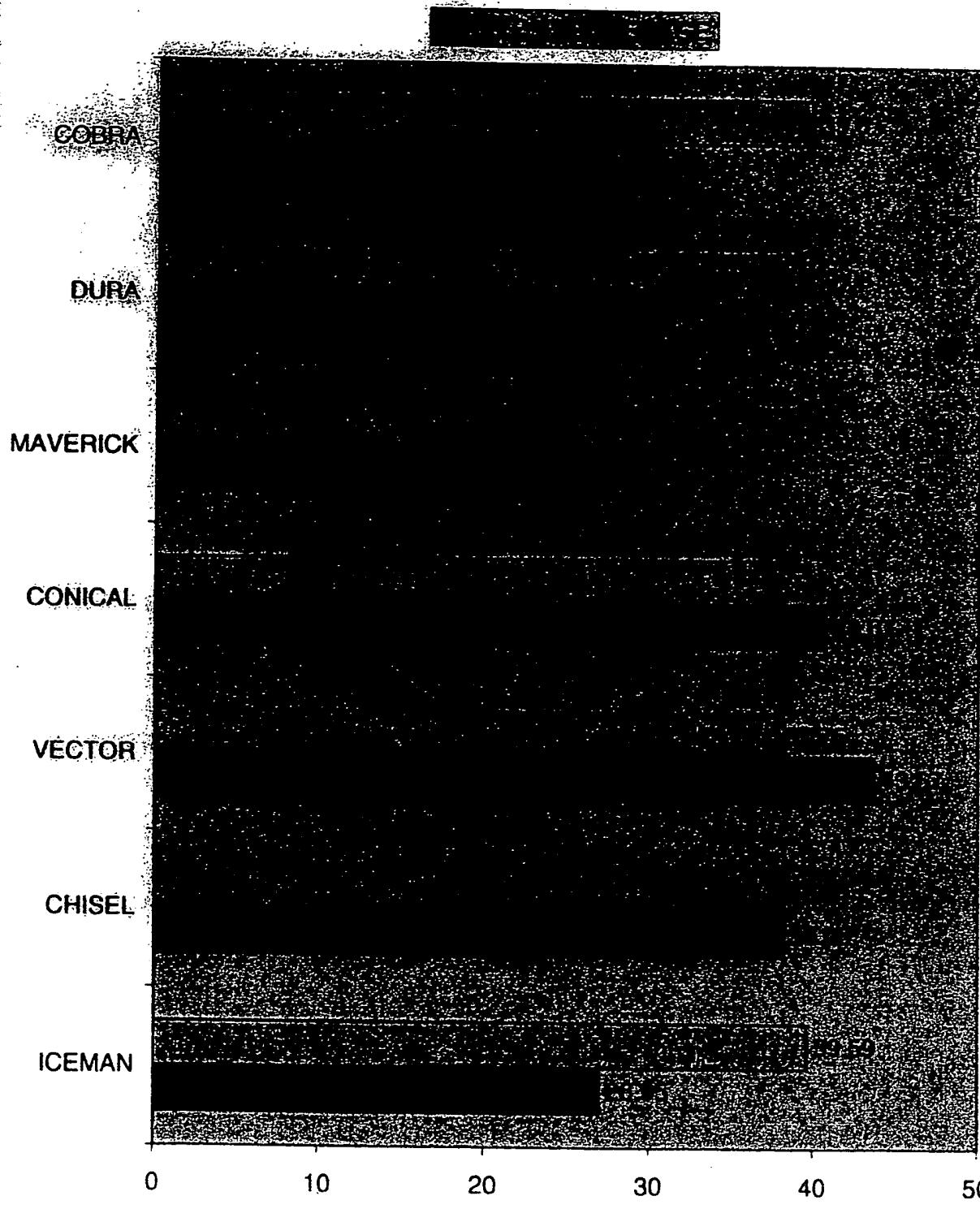
COVERAGE = 4% Increase  
[Vector]

## ROW COUNTS

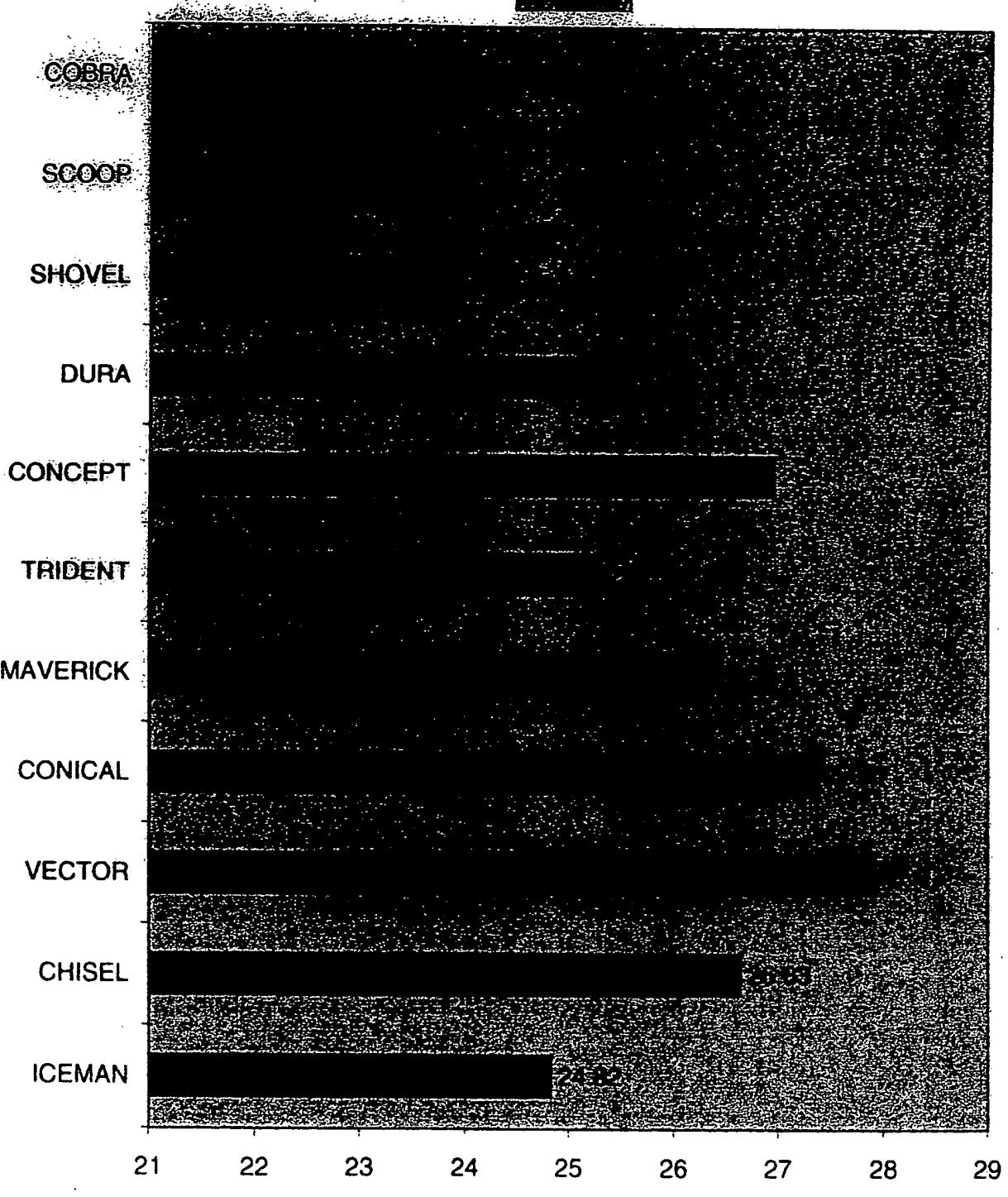
R.O.P. = 16% Increase [-1  
Insert on each row]

COVERAGE = 5% Increase [-1  
Insert on each row]

## COMPARISON OF INSERT SHAPES IN BRITTLE ROCK



## COMPARISON OF INSERT SHAPES IN DUCTILE ROCK



## CROSS-SECTION AREA FOR VARIOUS INSERTS

ICEMAN

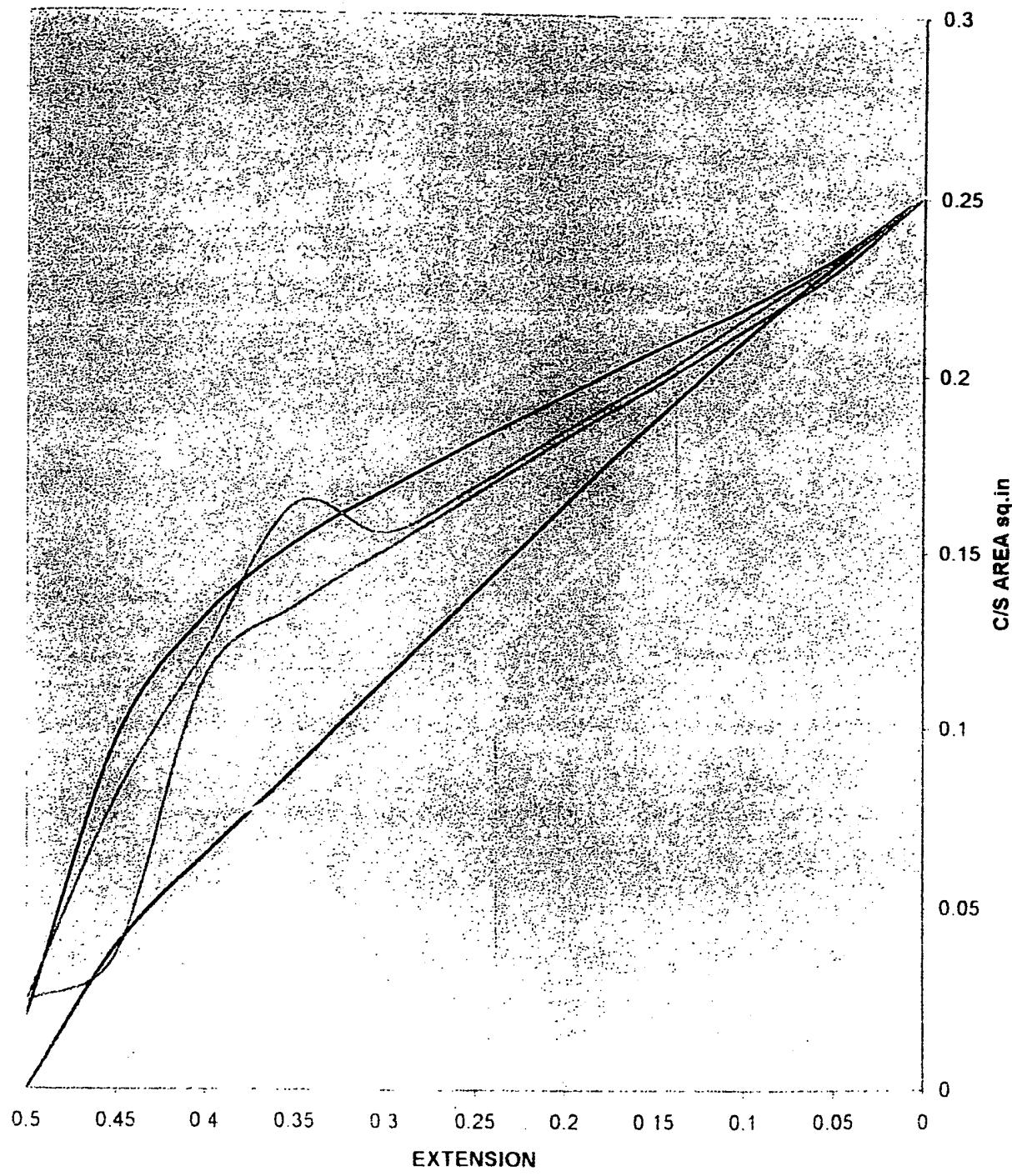
CHISEL

VECTOR

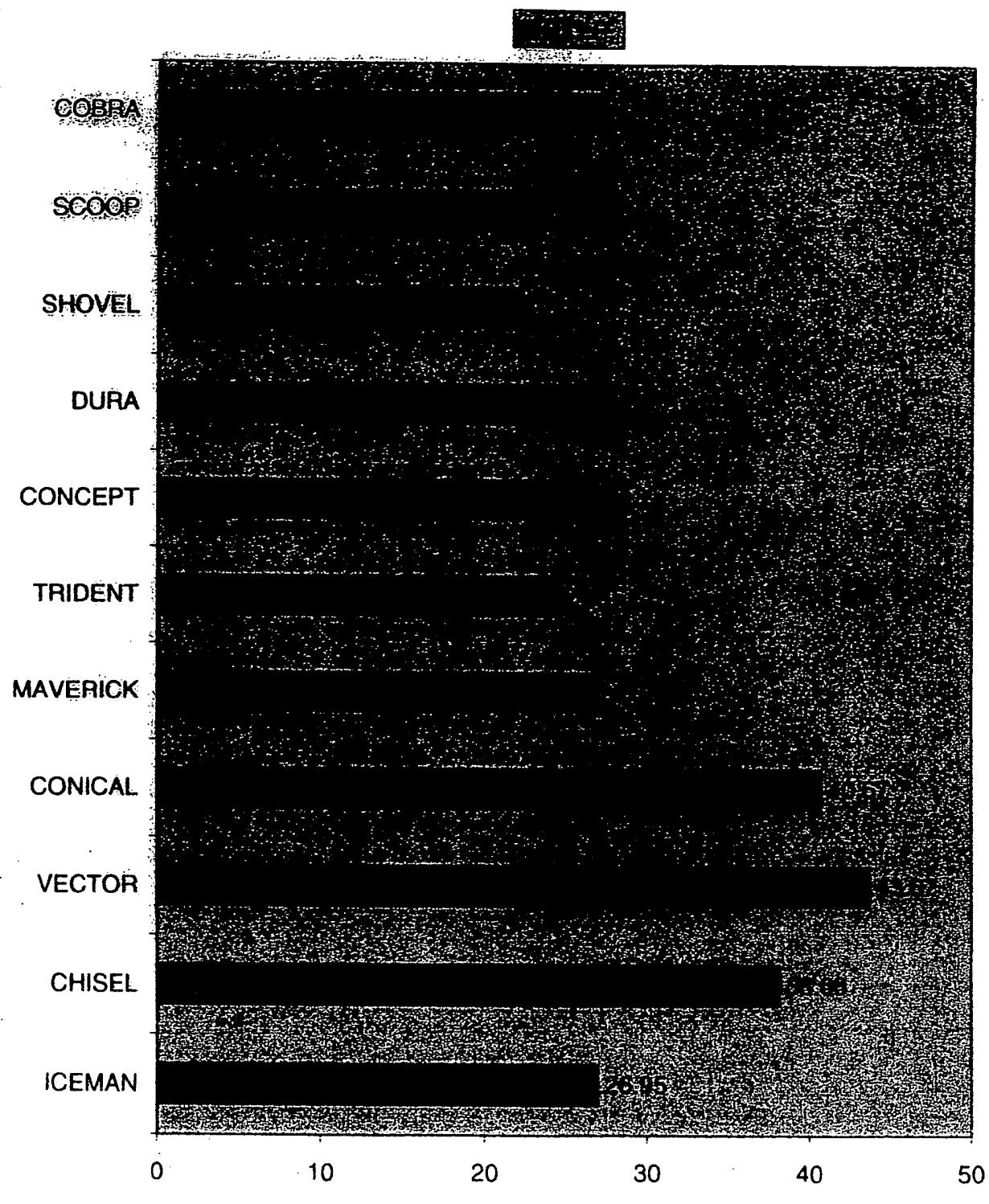
CONCEPT

TRIDENT

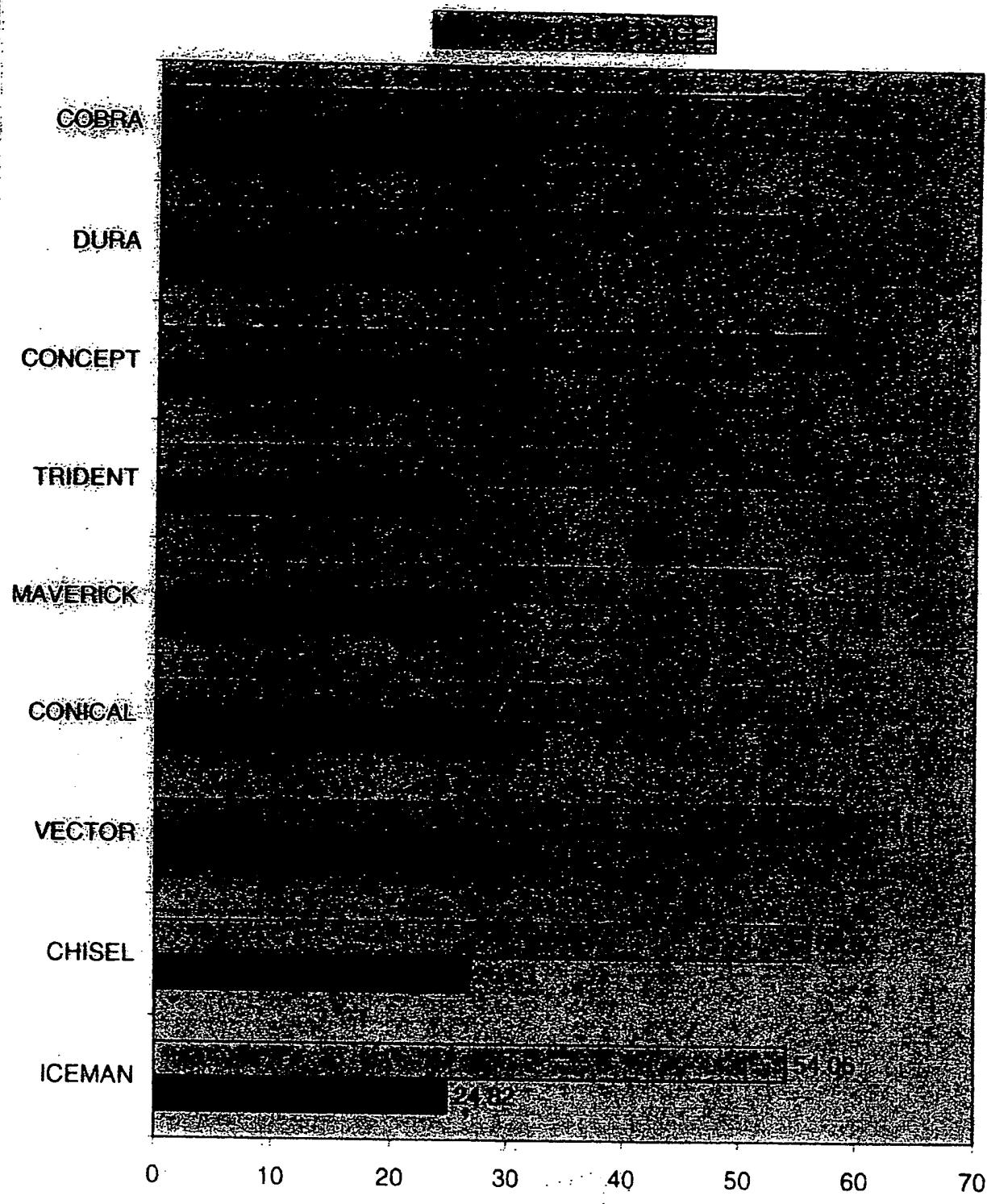
DURA



## COMPARISON OF INSERT SHAPES IN BRITTLE ROCK



## COMPARISON OF INSERT SHAPES IN DUCTILE ROCK



# Program validation and development

## Duplicating field results

W.O.B. = 7-13 kN

R.P.M. = 80-240 rpm

R.O.P. = 35 m/hr

## IDEAS Parameters & Results

### Rock Types

Ductile

Brittle

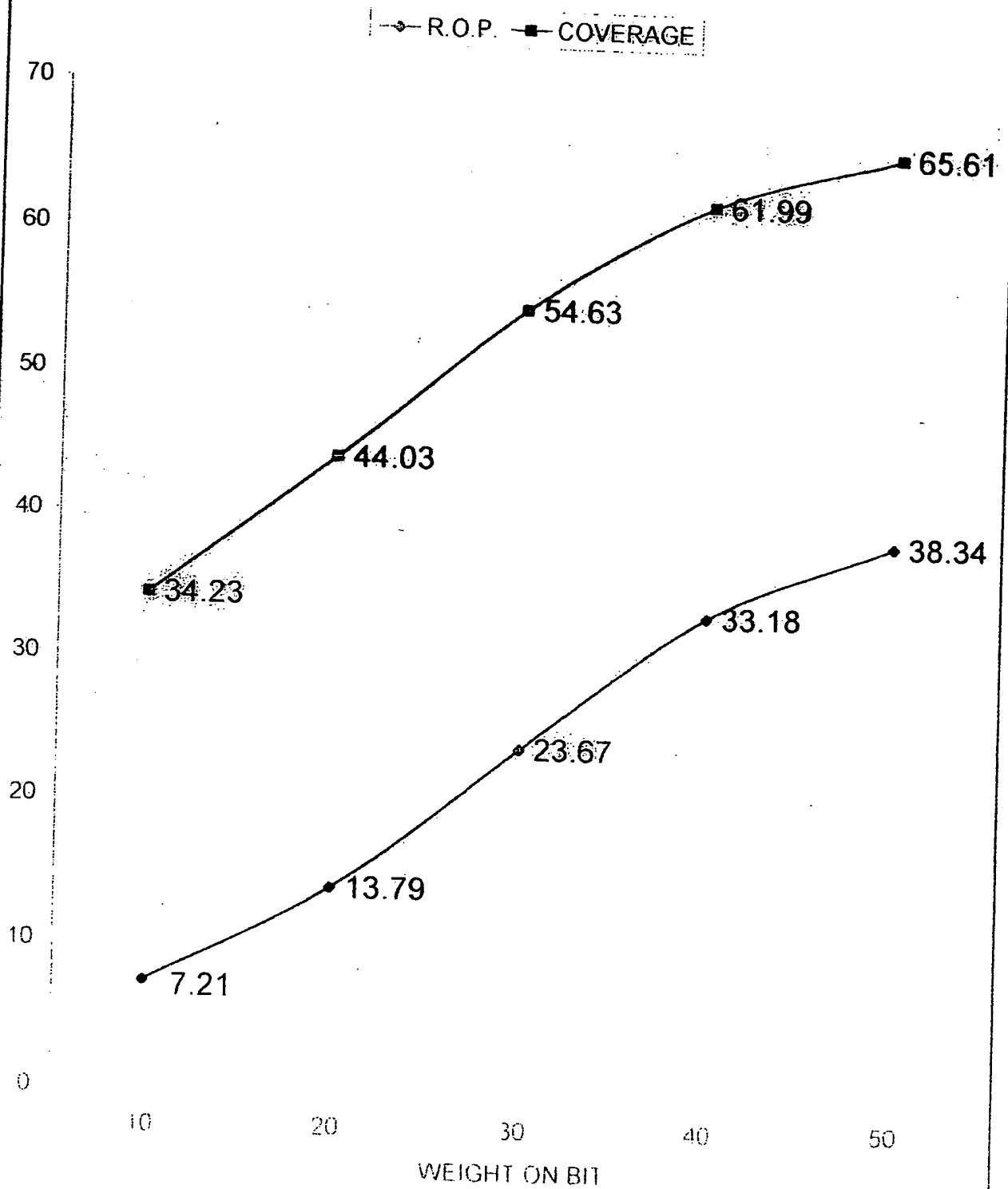
W.O.B. = 10,000 kg f

R.P.M. = 140 rpm

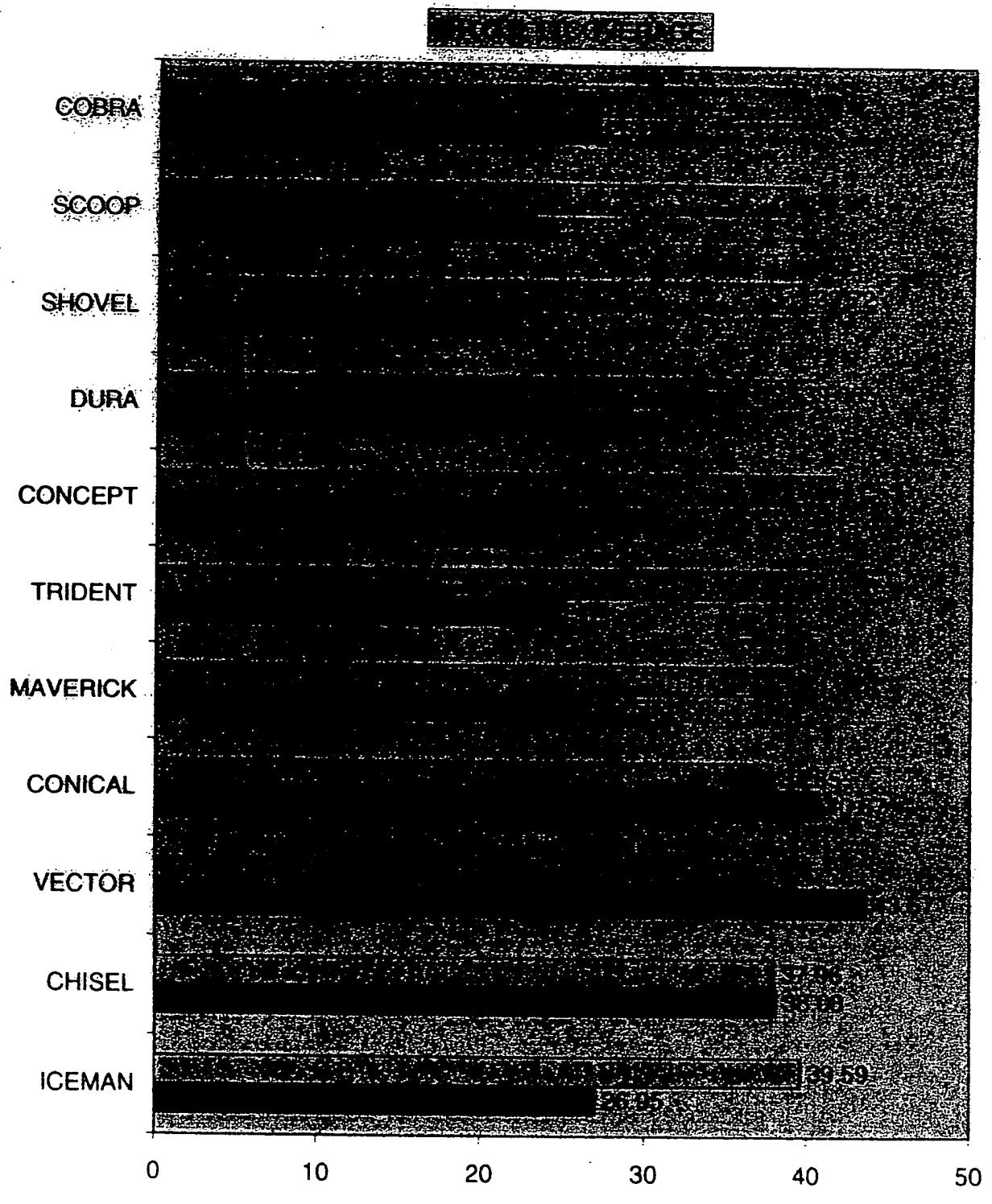
R.O.P. = 24-28 m hr

## Verifying performance trends

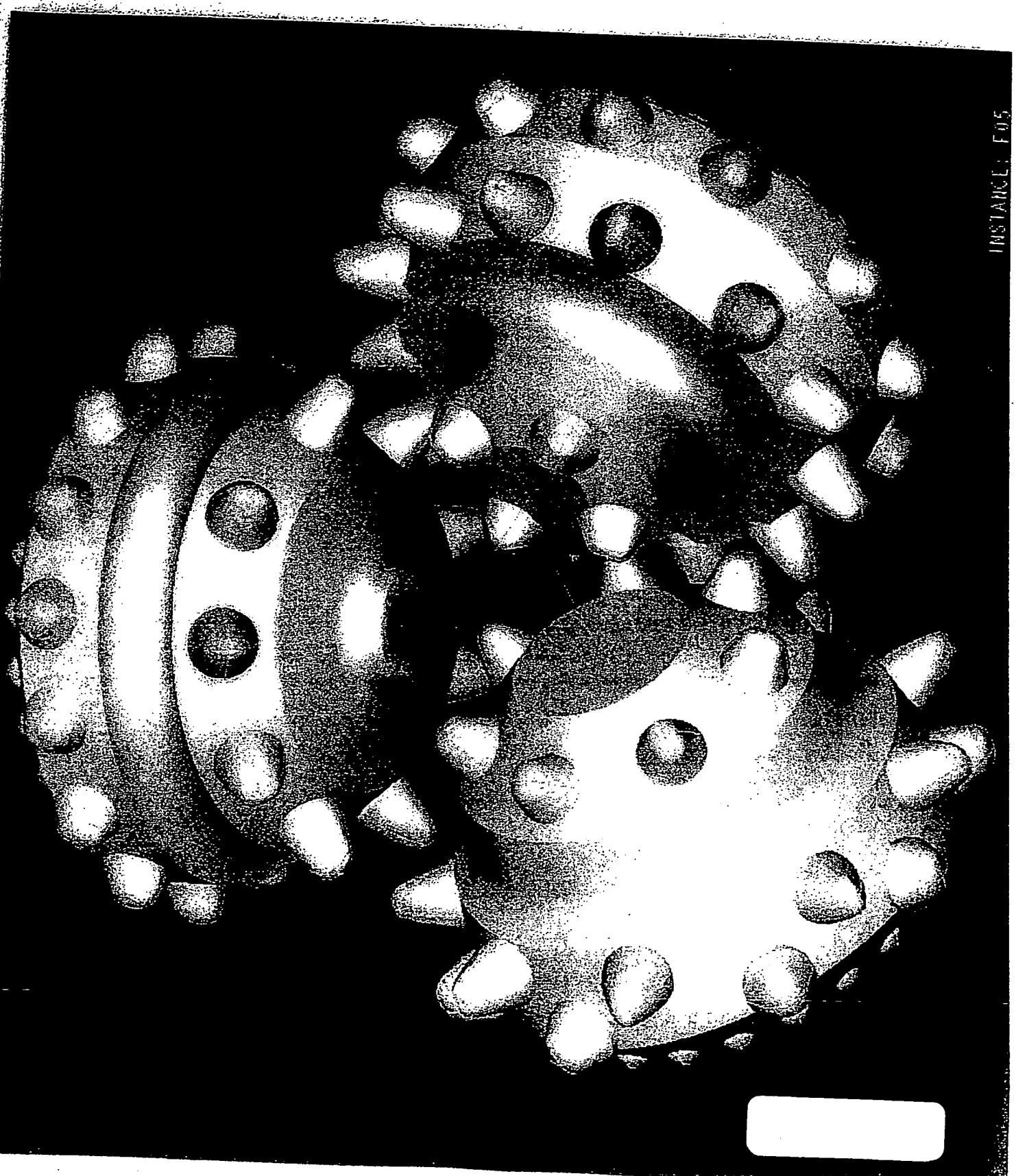
### PERFORMANCE OF F00 BIT IN MEDIUM DUCTILE ROCK



## COMPARISON OF INSERT SHAPES IN BRITTLE ROCK

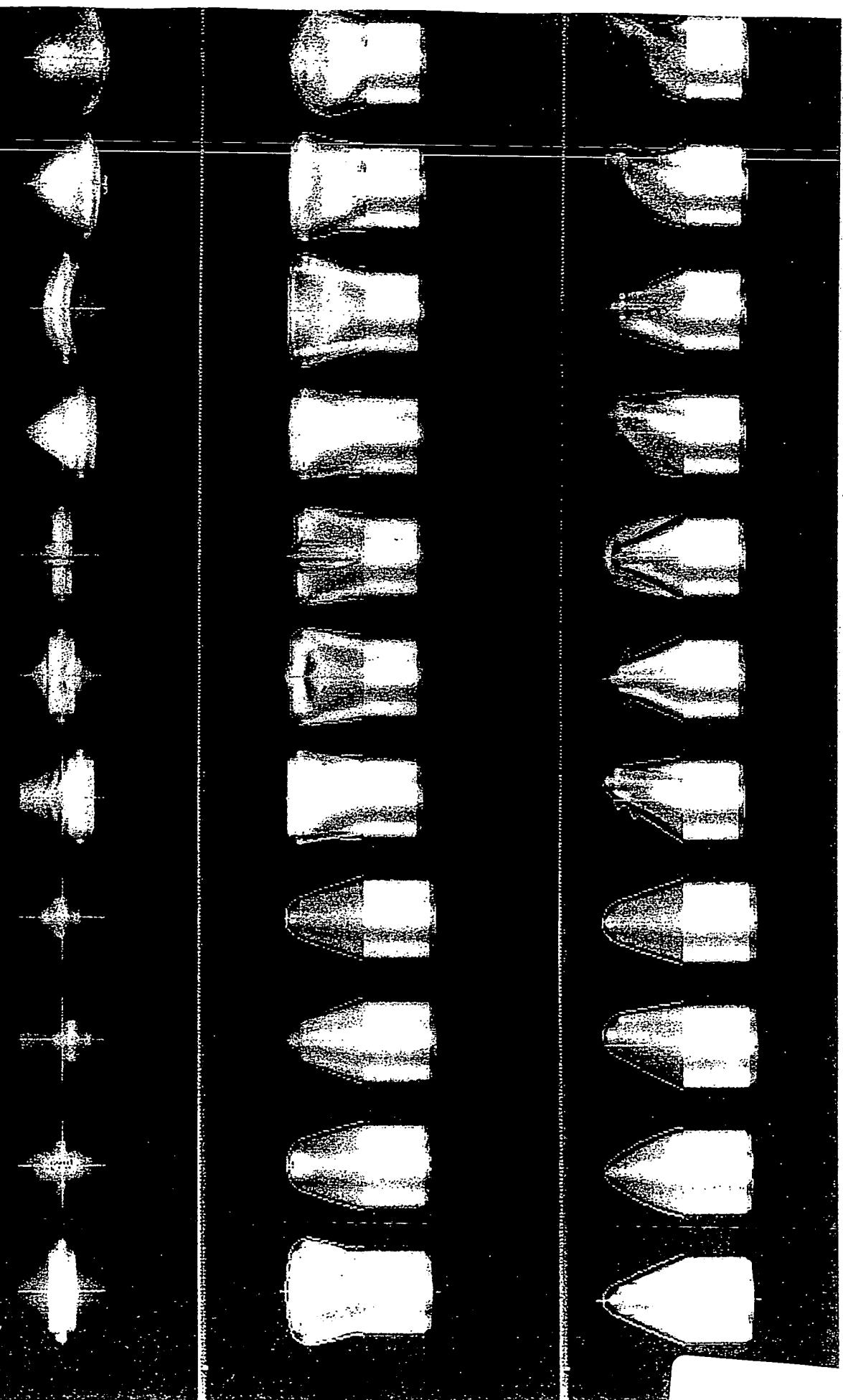


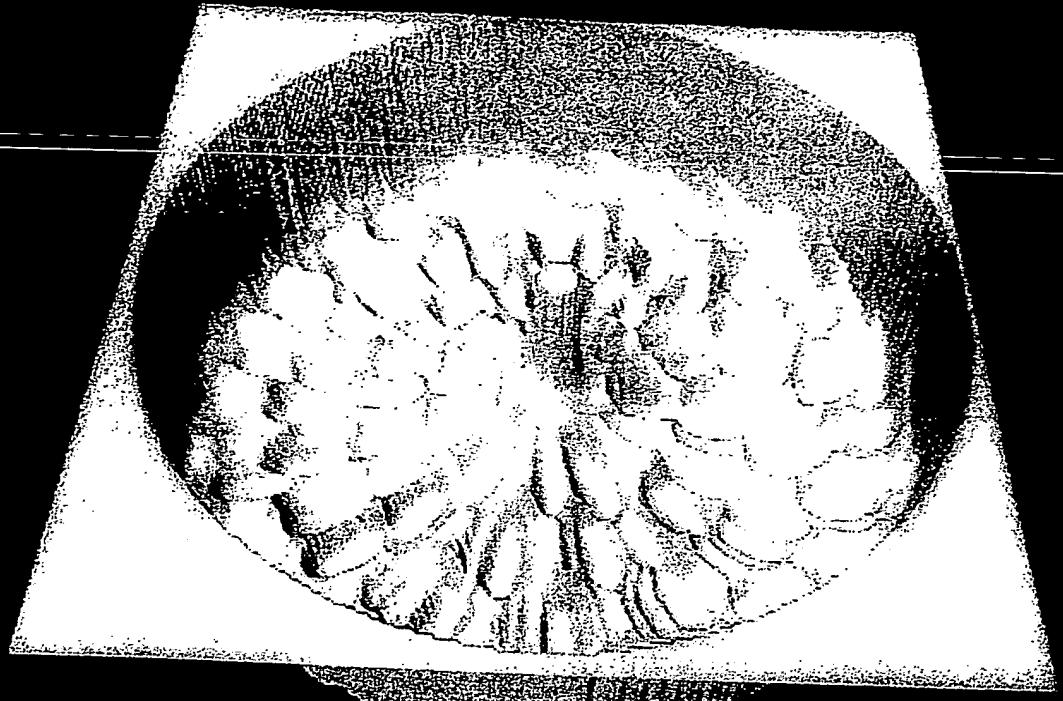
INSTANCE: FIG



ICEMAN

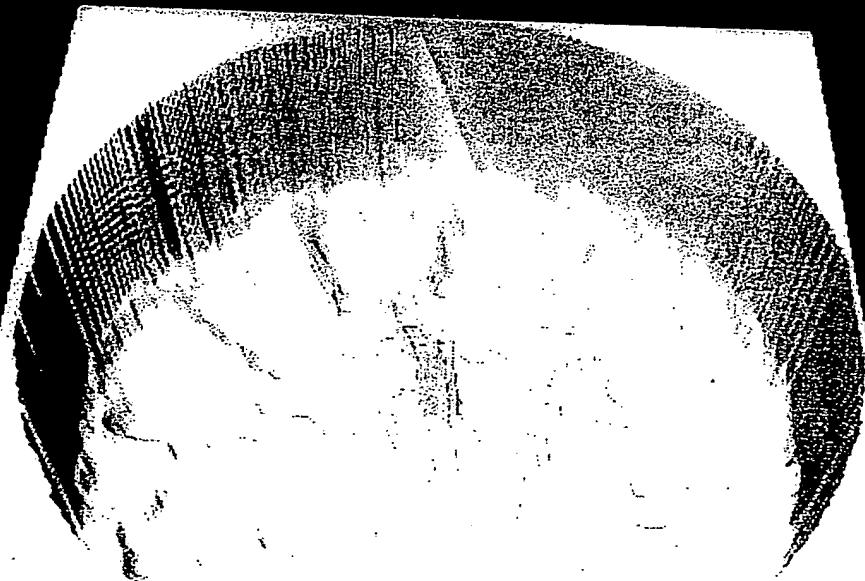
CHAINSAW CHISEL SET



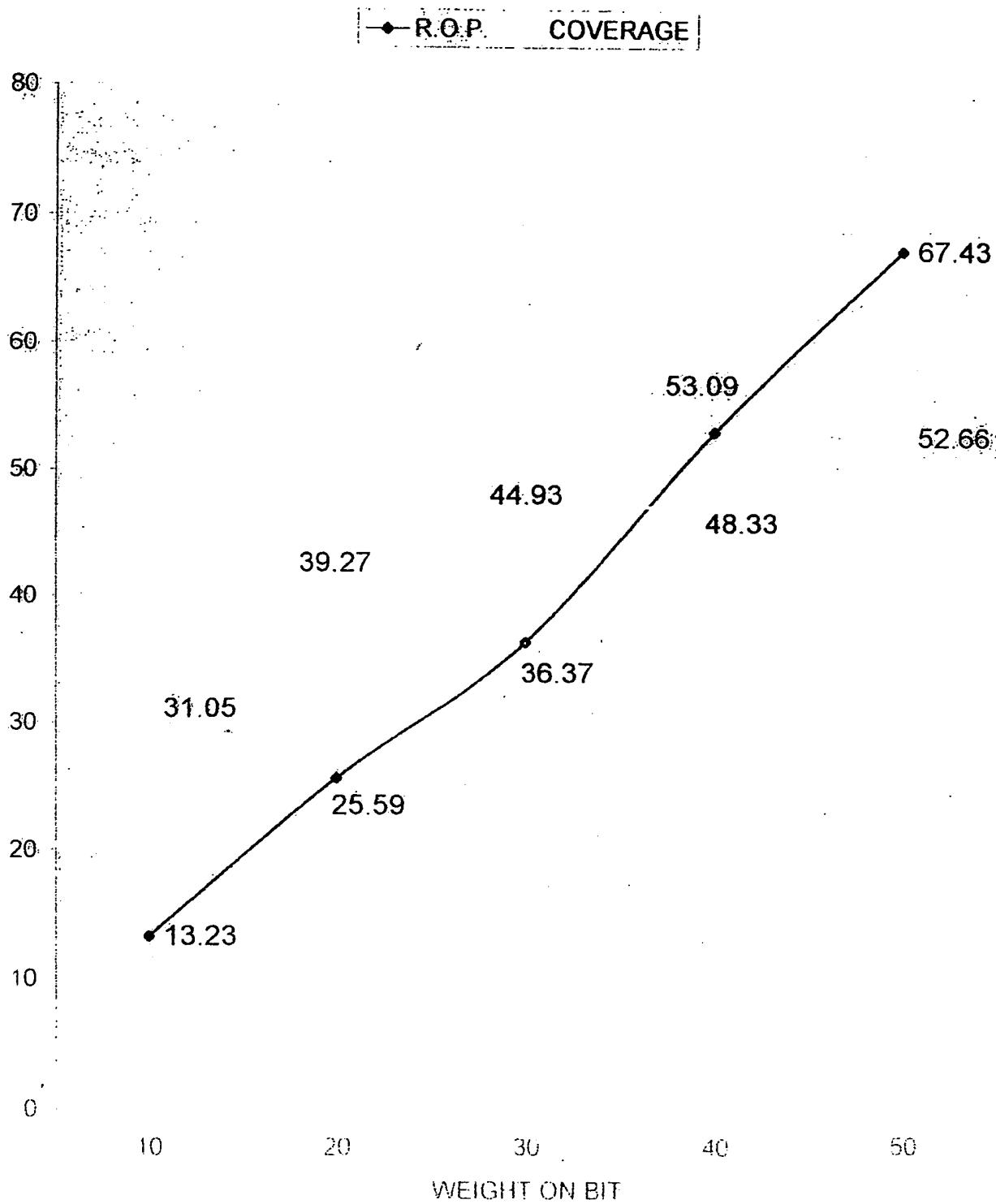


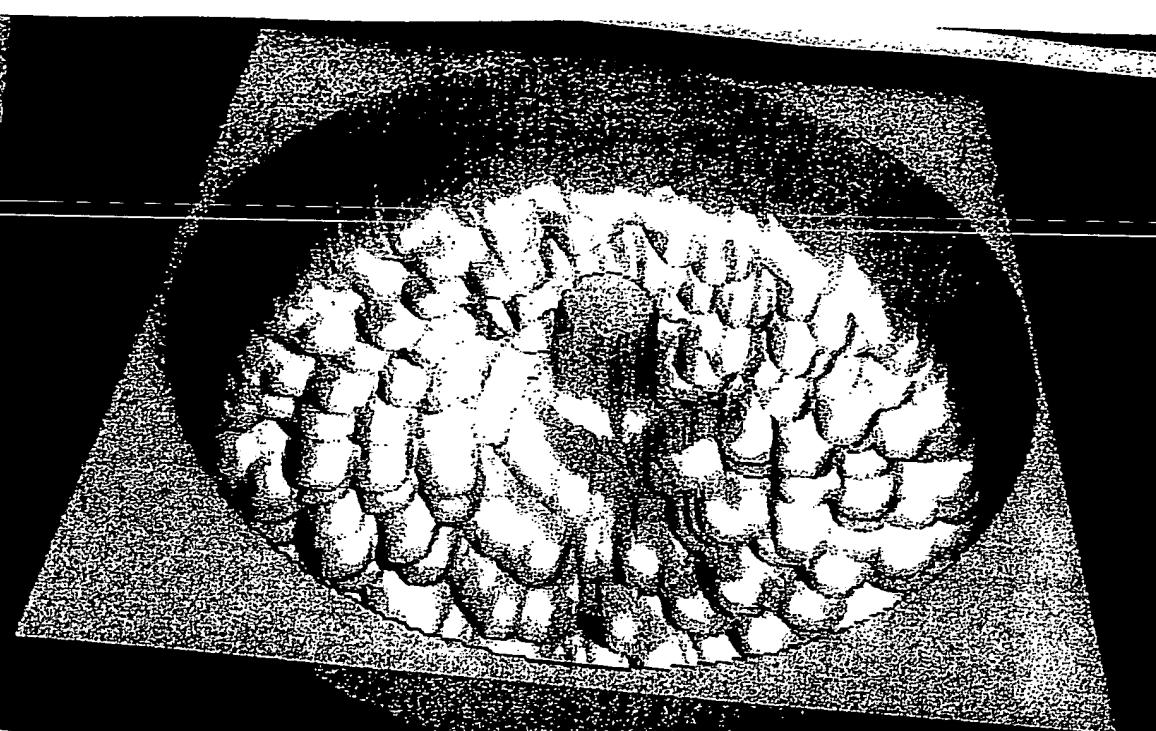
Robx Roly

Dolly

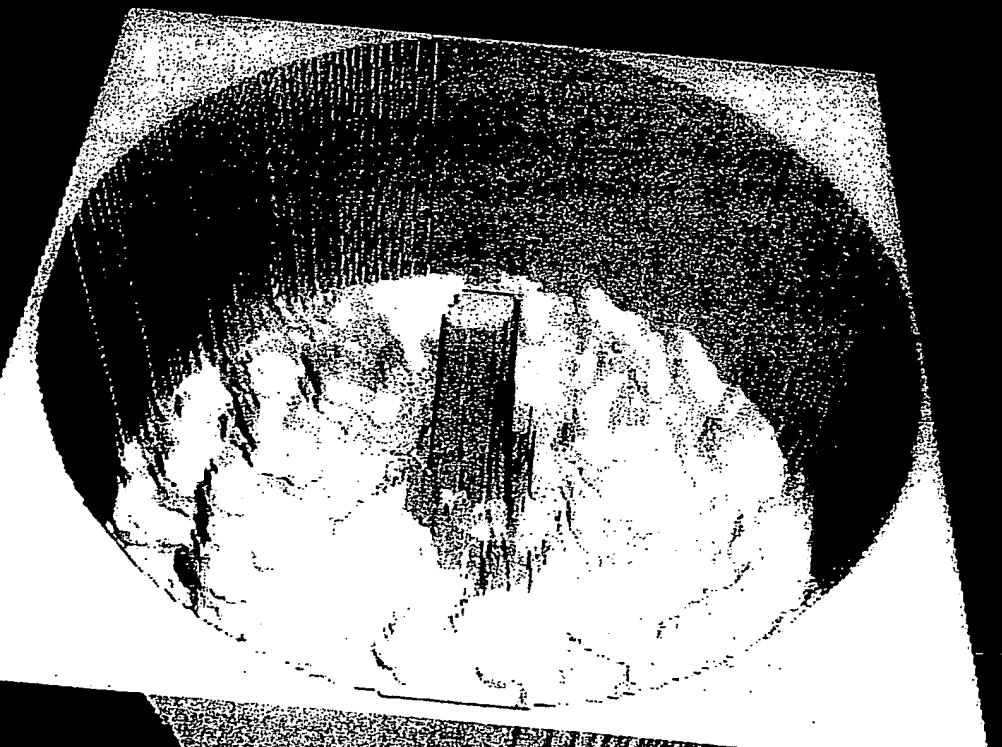


### PERFORMANCE OF F00 BIT IN BRITTLE ROCK





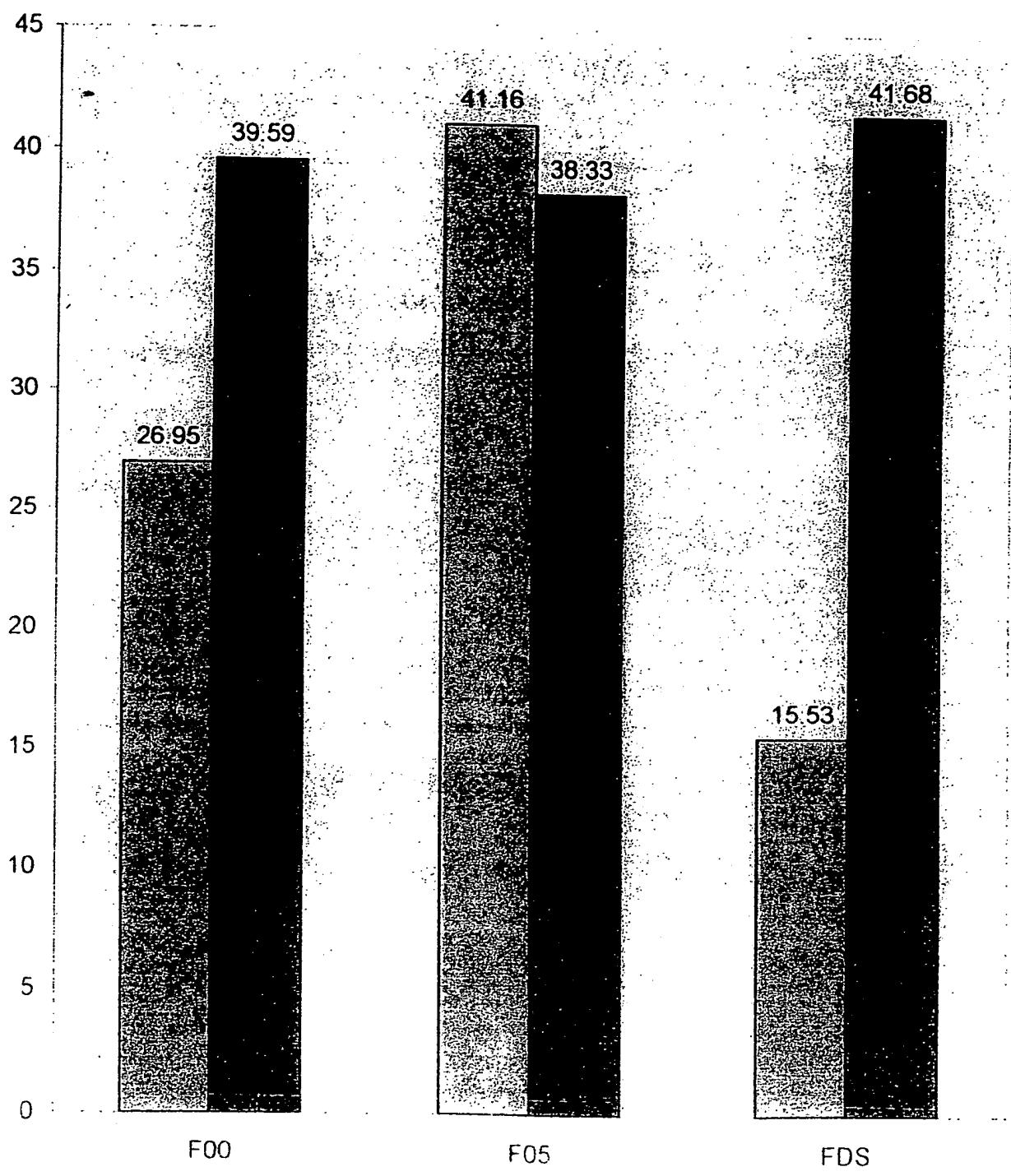
File Options Optimize



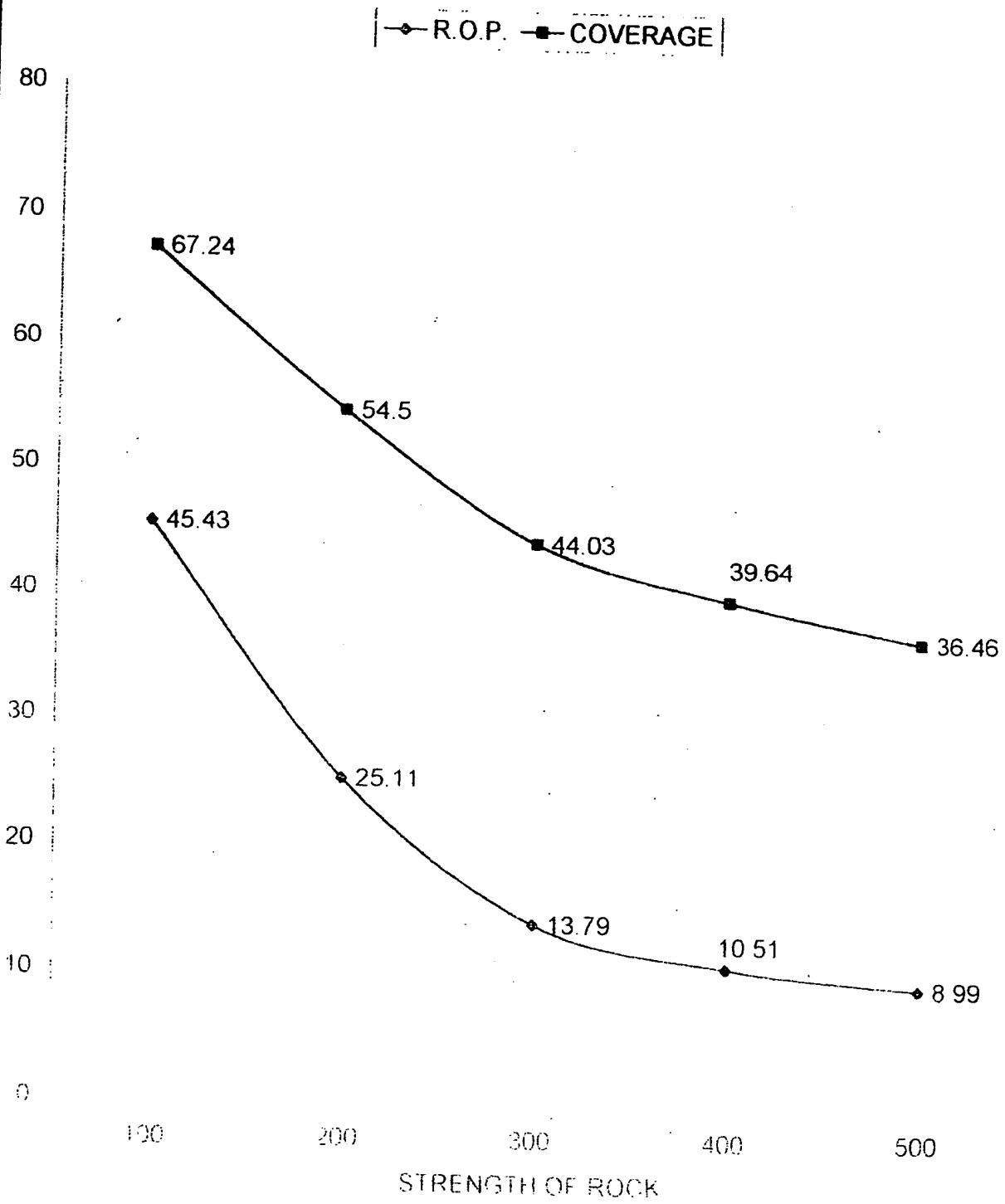
10

## BENCHMARKING OF F00 BIT IN BRITTLE ROCK

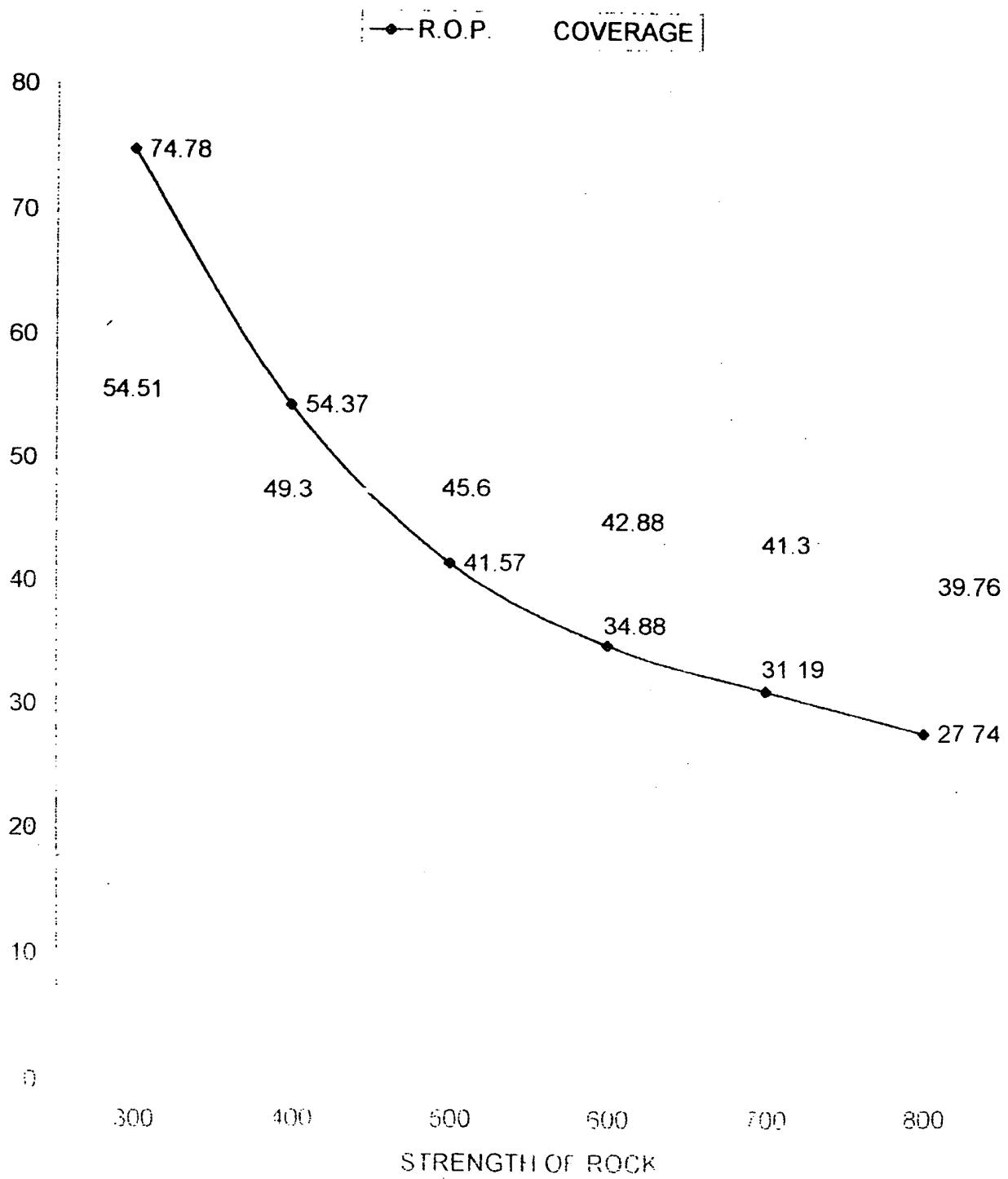
R.O.P.  COVERAGE



PERFORMANCE OF F00 BIT IN DUCTILE ROCK OF INCREASING STRENGTH



PERFORMANCE OF F00 BIT IN BRITTLE ROCK OF INCREASING  
STRENGTH



**BIT TYPE: F90-1 STD**  
**ROCK: DUCTILE**

400

300

200

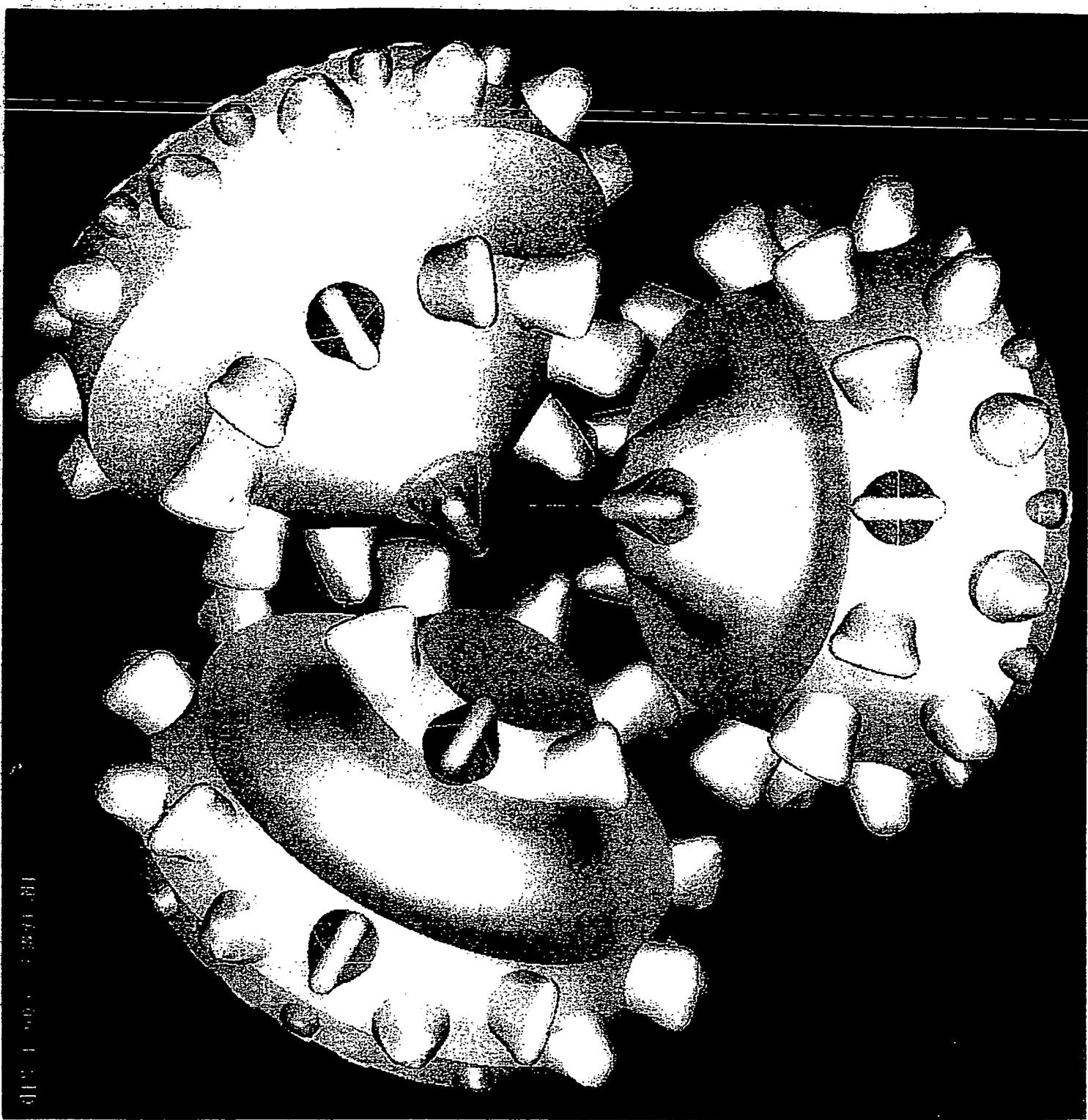
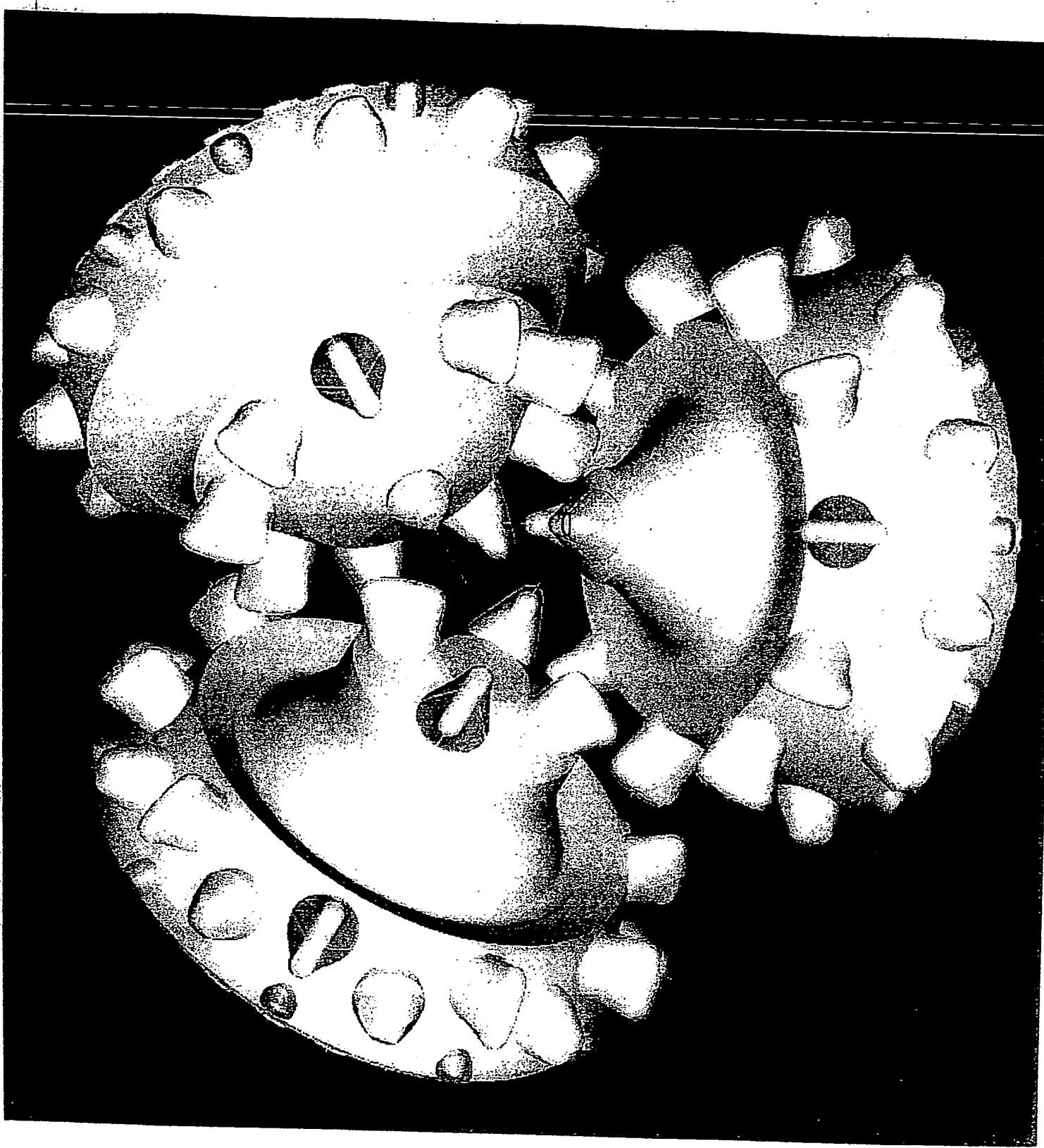
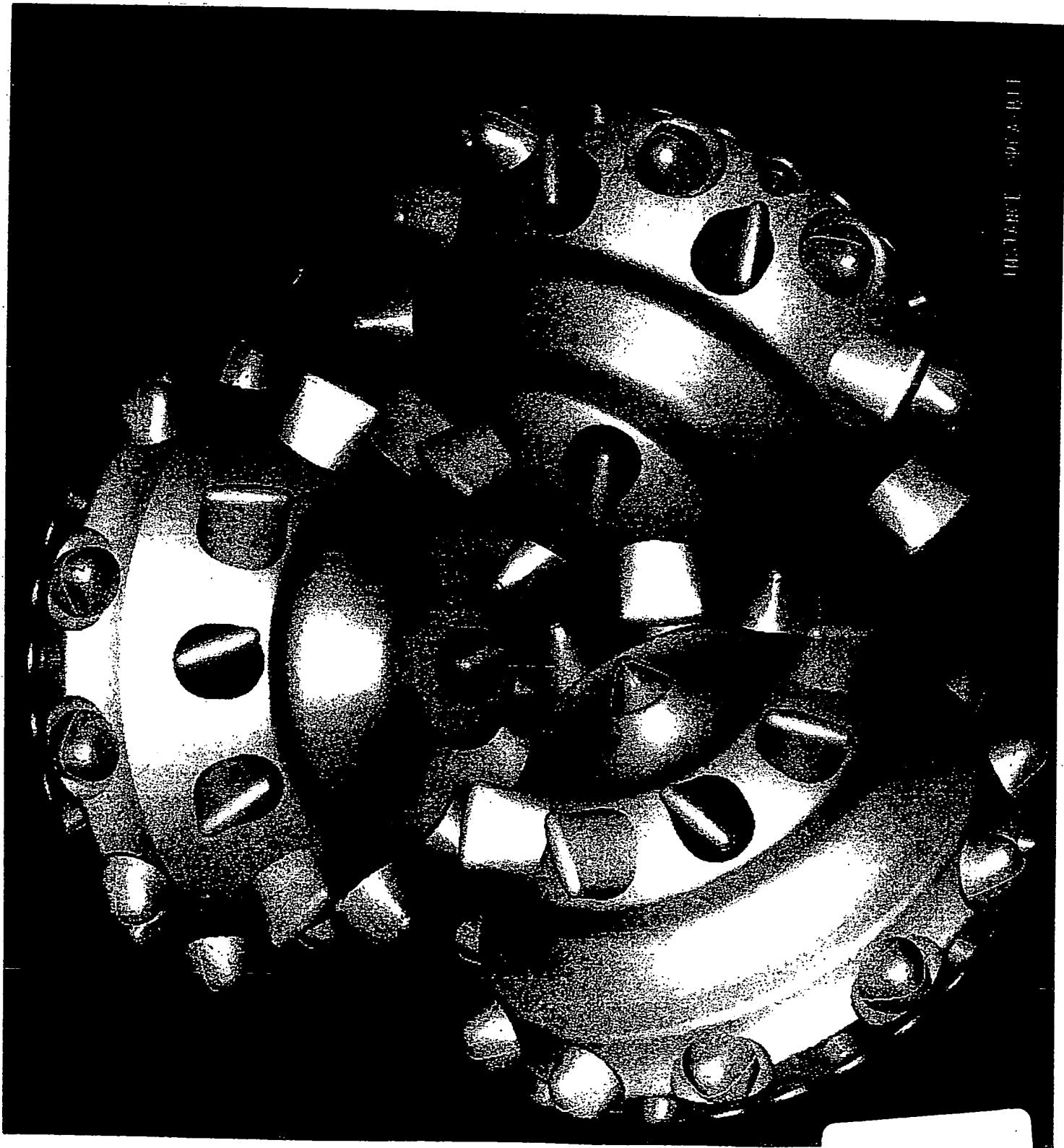


PLATE I. FIG. 1.



THE PINEYWOODS



Stress Max Prin (Maximum)

Avg. Max +2.0036E+05

Avg. Min -7.0105E+04

Original Model

Load: Load1

2.662E+04

2.682E+04 2.684E+04

2.682E+04 2.688E+04 2.568E+04

2.680E+04 2.680E+04

2.727E+04

2.661E+04 2.592E+04 2.315E+04

2.419E+04

2.333E+04

+1. 553E+05

+1. 513E+04

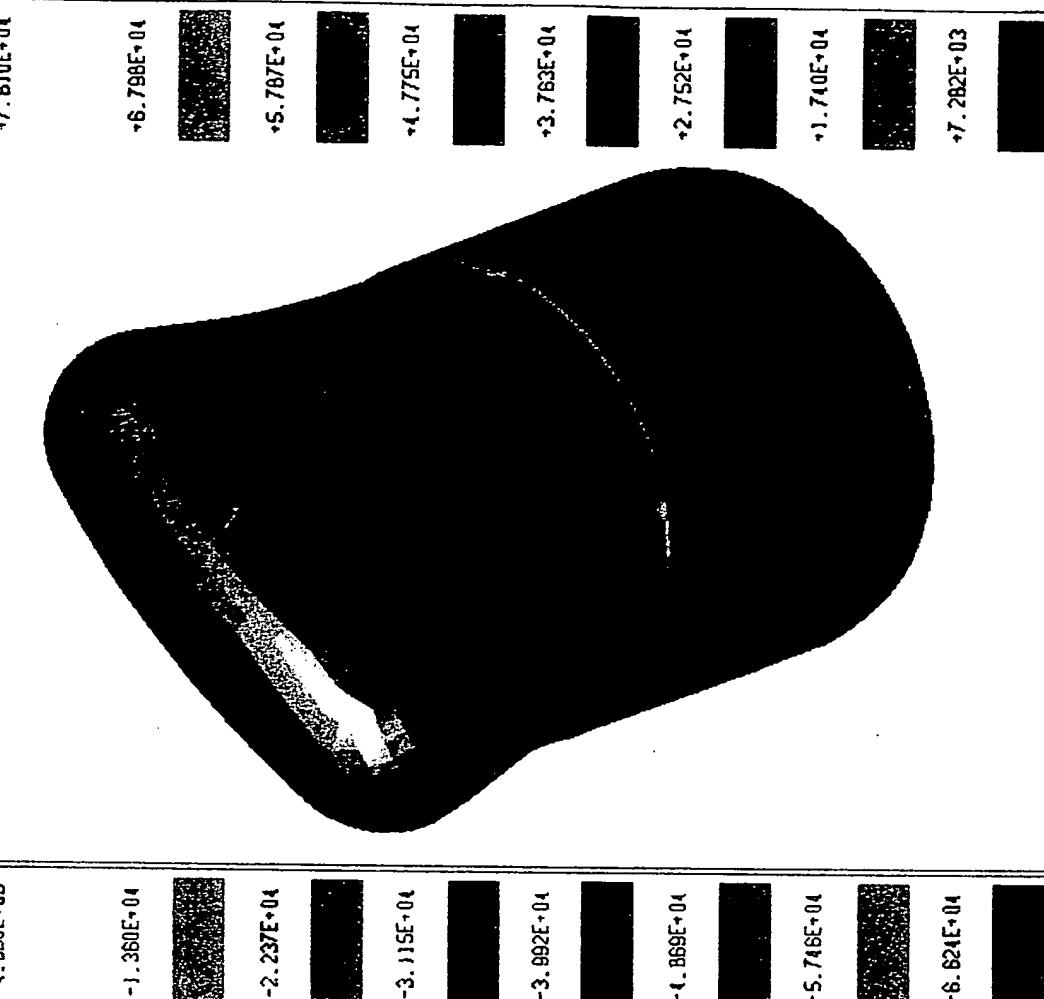
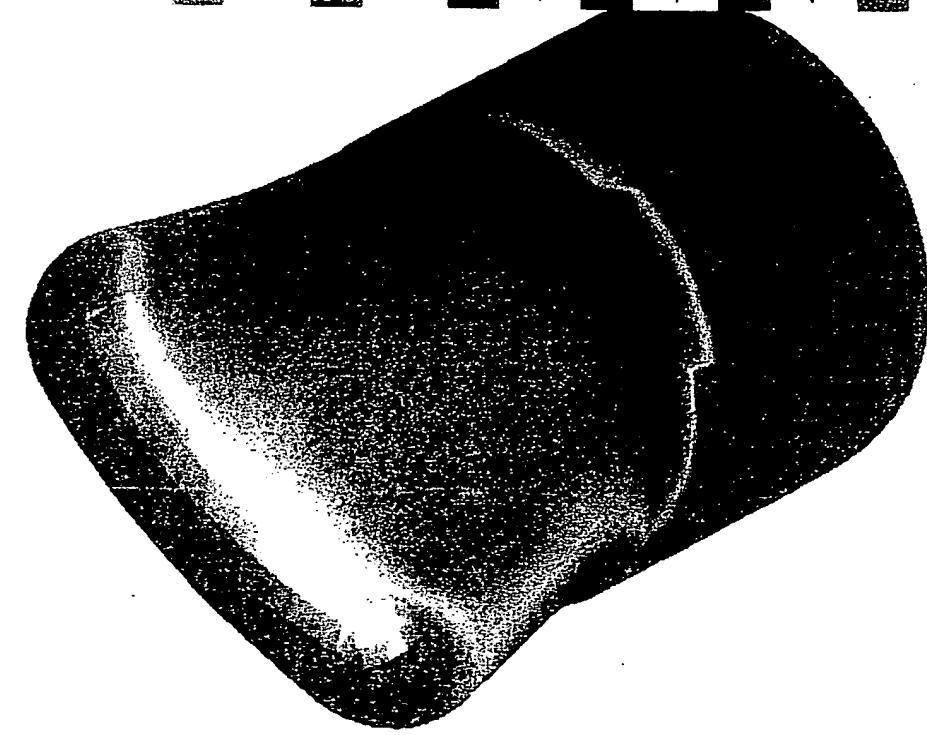
+1. 103E+05

-2. 503E+04

"winken2" - csc\_press - csc\_press

Stress Min Prin (Minimum)  
Avg. Max +3.9428E+03  
Avg. Min -7.5009E+04  
Original Model  
Load: Load1

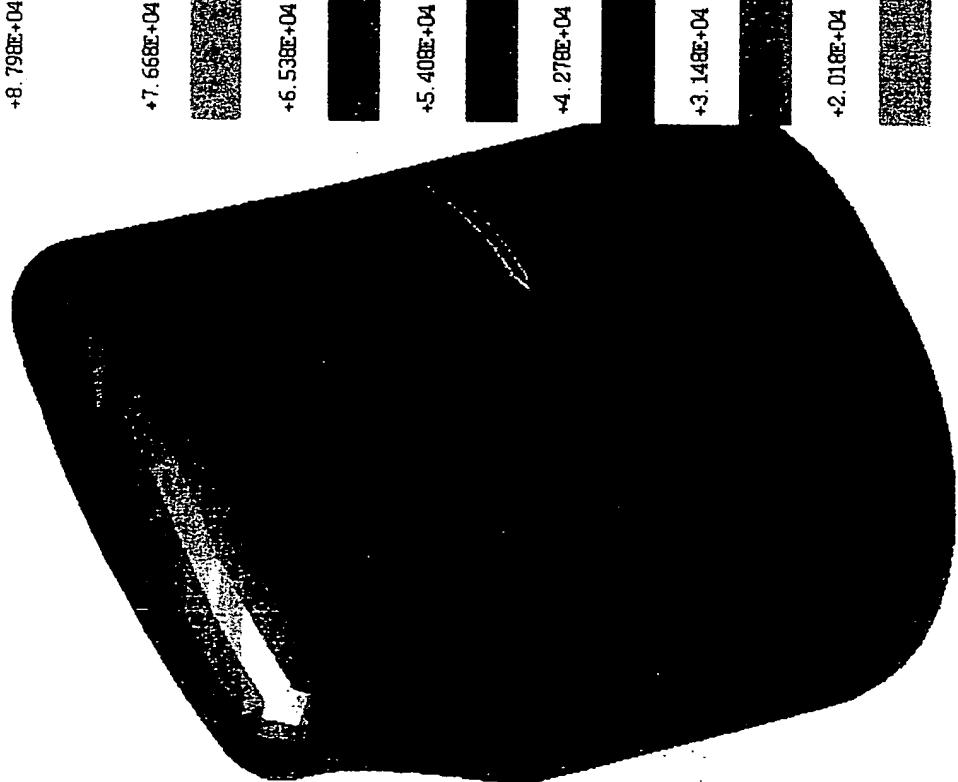
Stress Max Prin (Maximum)  
Avg. Max +8.8219E+04  
Avg. Min -2.8357E+03  
Original Model  
Load: Load1



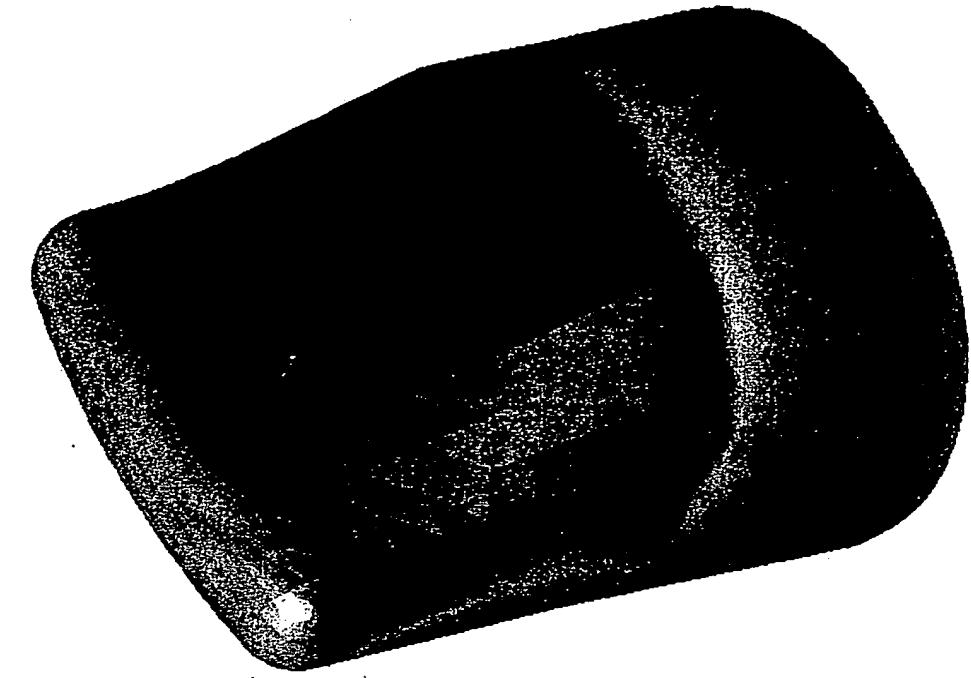
"window2" - ins\_licemant - ins\_licemant

"window" - ins\_licemant - ins\_licemant

Stress Max Prin (Maximum)  
Avg. Max +9.9275E+04  
Avg. Min -2.4143E+03  
Original Model  
Load: load1



Stress Min Prin (Minimum)  
Avg. Max +6.2710E+03  
Avg. Min -4.8760E+04  
Original Model  
Load: load1

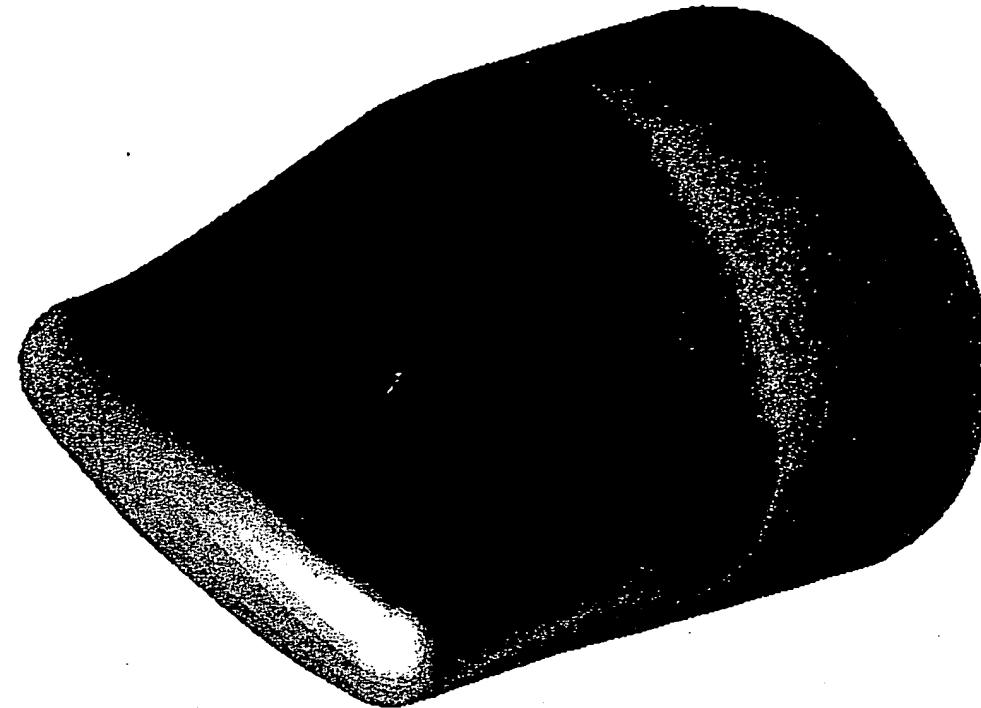
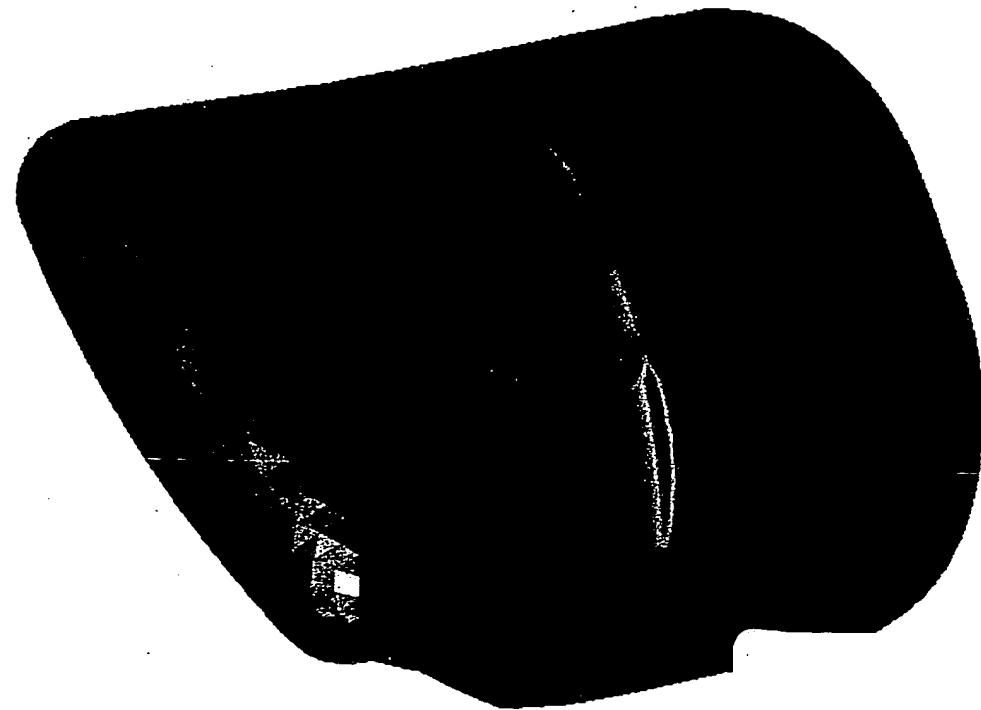


"window1" - OFFSET - OFFSET

"window2" - OFFSET - OFFSET

Stress Max Prin (Maximum)  
Avg. Max +1.2738E+05  
Avg. Min -2.4160E+03  
Original Model  
Load: load1

Stress Min Prin (Minimum)  
Avg. Max +6.3221E+03  
Avg. Min -5.3021E+04  
Original Model



Legend:  
"window1" - ins\_bend\_0 - ins\_bend\_0

"window2" - ins\_bend\_0 - ins\_bend\_0

Stress in (top)  
View 1.8715-01  
Min : 0.8128E-03  
Original Model  
Load: load1

Stress in (top)  
View 1.8715-01  
Min : 0.8128E-03  
Original Model  
Load: load1

\*1.510E+04

\*1.202E+04

\*B.943E+03

\*5.867E+03

\*2.791E+03

-2.848E+02

-3.361E+03

-6.437E+03

-1.109E+04

-1.667E+04

\*Indice1 - Ind Bend - Ind Bend

Stress Max Prin (top)  
Max : 5.1236E-01  
Min : 2.7232E-02  
Original Model  
Load: load1

\*Indice1 - Ind Bend - Ind Bend

\*B.343E+04

\*7.266E+04

\*6.169E+04

\*5.112E+04

\*4.035E+04

\*2.958E+04

\*1.881E+04

\*8.037E+03

-4.861E+04

\*3.058E+04

\*1.255E+04

\*Indice2 - Ind.1case1 + Ind.1case1

Stress Max Prin (top)  
Max : 4.5808E-05  
Min : 5.4891E-05  
Original Model  
Load: load1

\*Indice2 - Ind.1case1 + Ind.1case1

\*1.388E+05

\*1.216E+05

\*1.027E+05

\*8.468E+04

\*6.655E+04

\*4.861E+04

\*3.058E+04

\*1.255E+04

\*Indice2 - Ind.1case1 + Ind.1case1

Stress at flaps  
Max -7.32 MPa  
Min -2.11 MPa  
Original Model  
Load - load1

Stress at flaps  
Max -2.38 MPa  
Min -1.04 MPa  
Original Model  
Load - load1

+6.275E+04

[REDACTED]

+5.226E+04

[REDACTED]

+4.176E+04

[REDACTED]

+3.129E+04

[REDACTED]

+2.080E+04

[REDACTED]

+1.032E+04

[REDACTED]

-1.699E+02

[REDACTED]

-1.066E+04

[REDACTED]

Indoor2 - Indoorscan - Indoorscan

Stress Max MPa in flap1  
Max -9.4205E+04  
Min -2.7228E+02  
Original Model  
Load - load1

Indoor2 - Indoorscan - Indoorscan

+1.388E+05

[REDACTED]

+1.208E+05

[REDACTED]

+1.027E+05

[REDACTED]

+6.466E+04

[REDACTED]

+5.665E+04

[REDACTED]

+4.661E+04

[REDACTED]

+3.058E+04

[REDACTED]

+1.255E+04

[REDACTED]

Indoor2 - Indoorscan - Indoorscan

Stress Max MPa in flap1  
Max -1.333E+04  
Min -8.839E+03  
Original Model  
Load - load1

Indoor2 - Indoorscan - Indoorscan

+1.333E+04

[REDACTED]

-7.327E+02

[REDACTED]

-5.419E+03

[REDACTED]

-1.010E+04

[REDACTED]

-1.479E+04

[REDACTED]

+6.344E+04

[REDACTED]

+2.958E+04

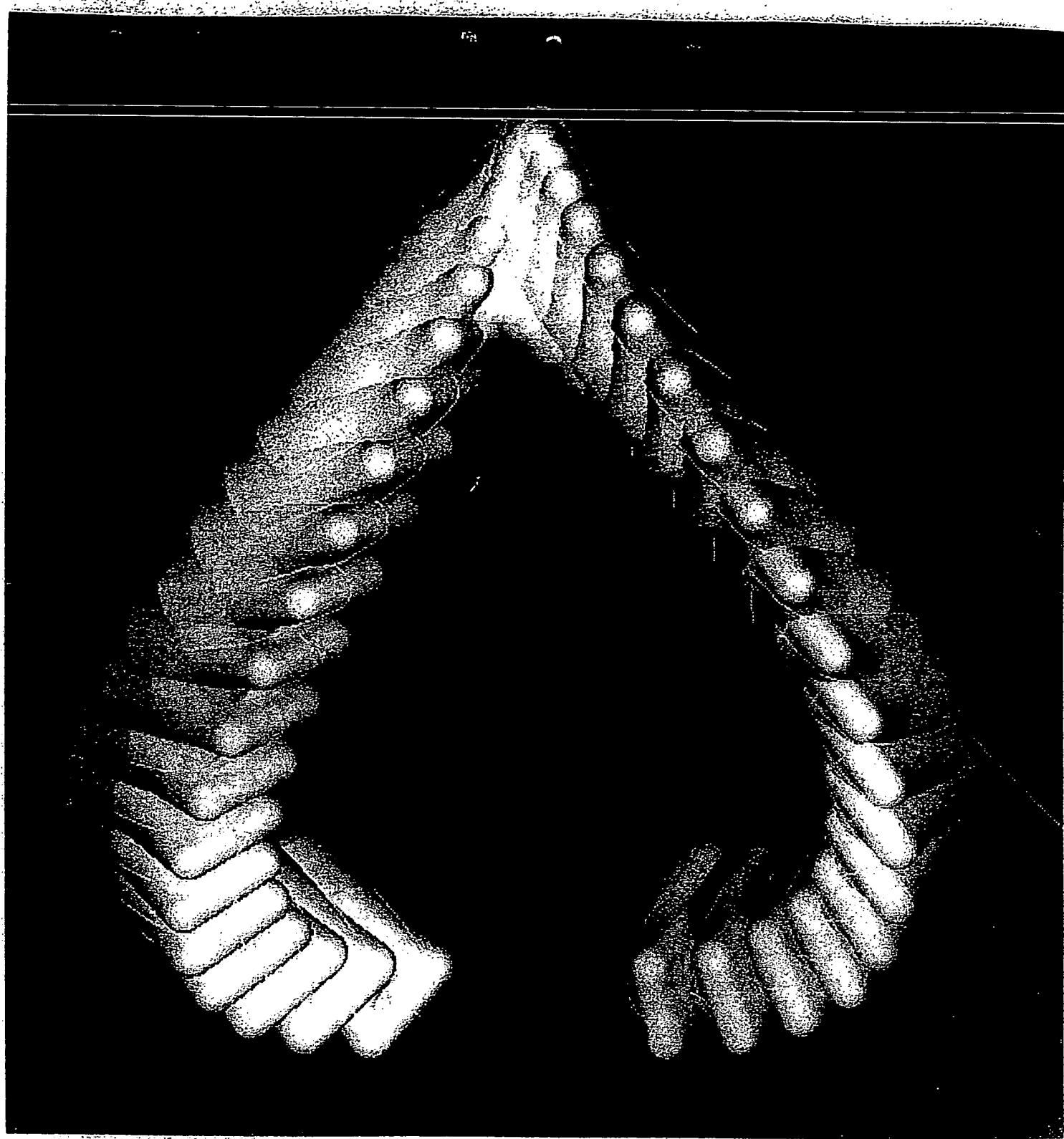
[REDACTED]

+1.881E+04

[REDACTED]

+8.037E+03

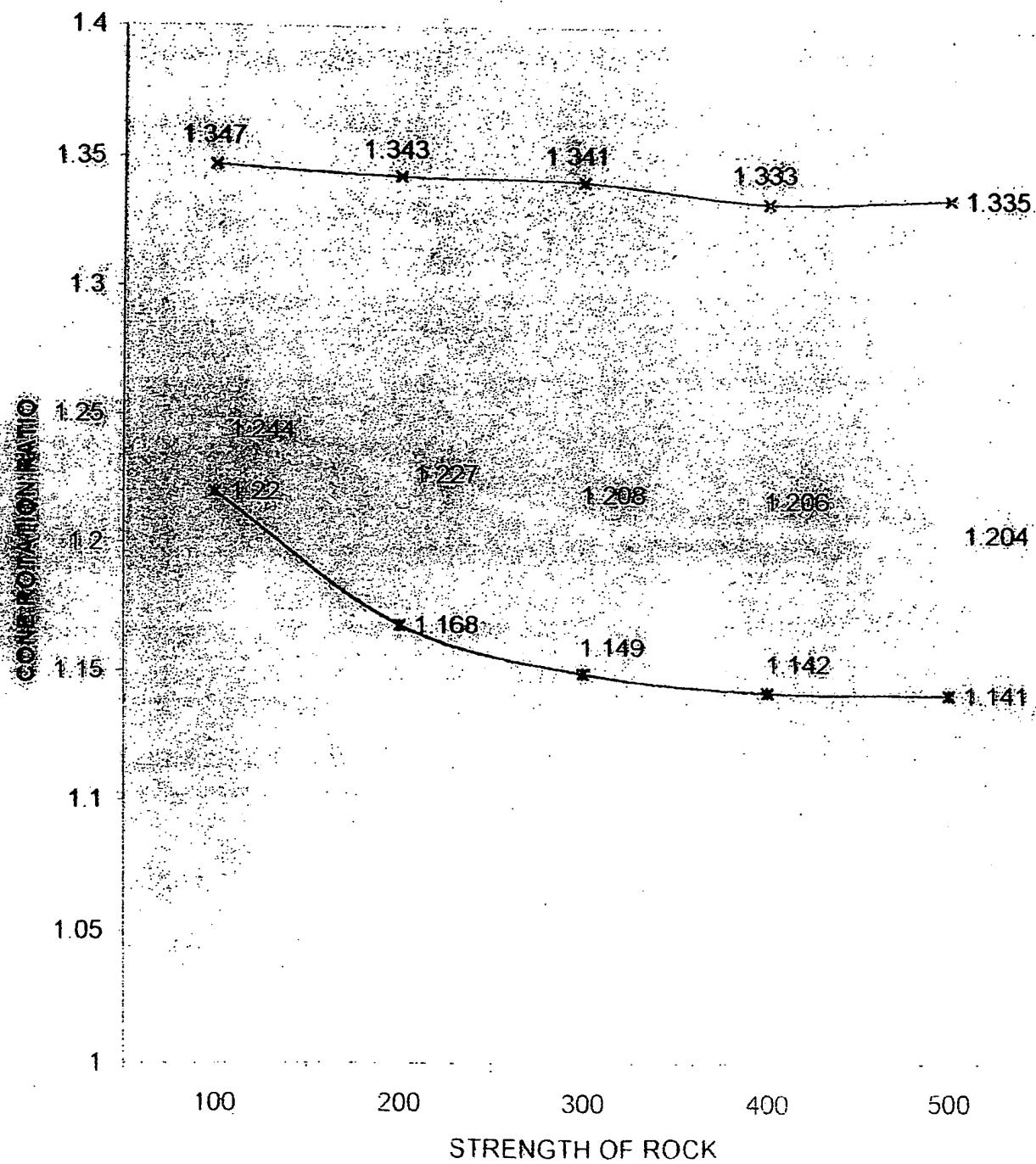
Indoor2 - Indoorscan - Indoorscan





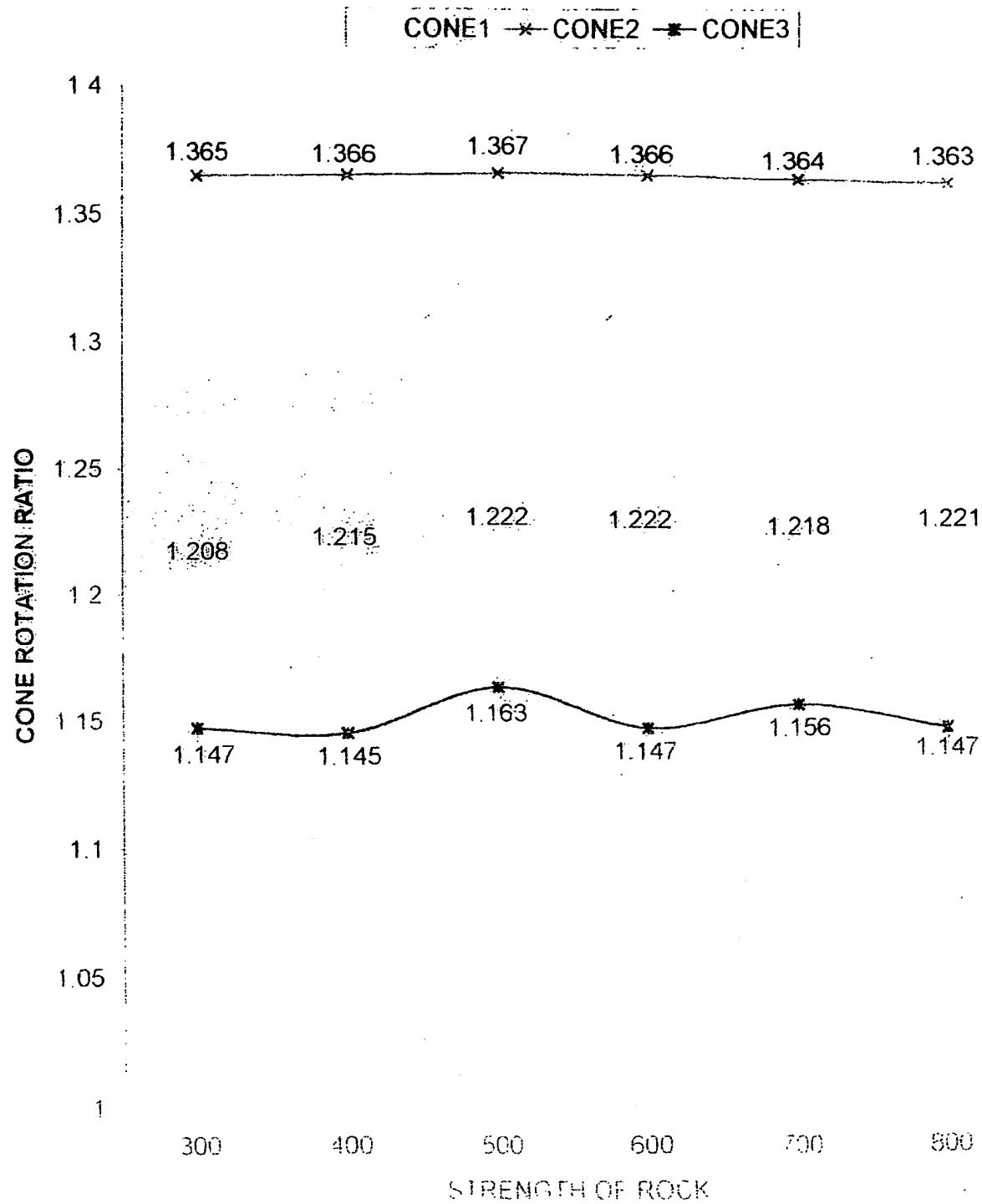
**PERFORMANCE OF F00 BIT IN DUCTILE ROCK OF INCREASING  
STRENGTH**

**CONE1 × CONE2 × CONE3**



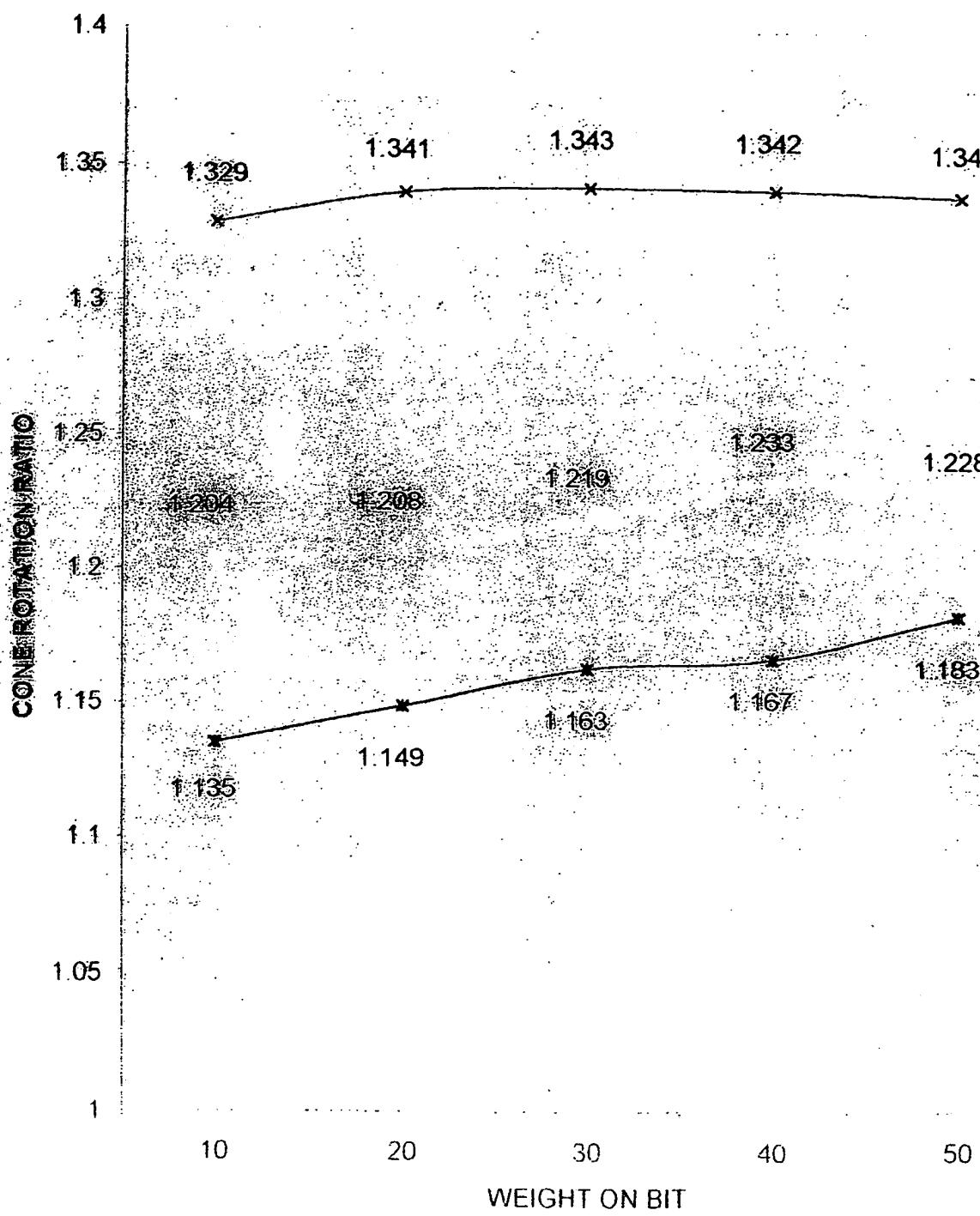
**BIT TYPE:  
ROCK: BRITTLE**

PERFORMANCE OF F00 BIT IN BRITTLE ROCK OF INCREASING  
STRENGTH

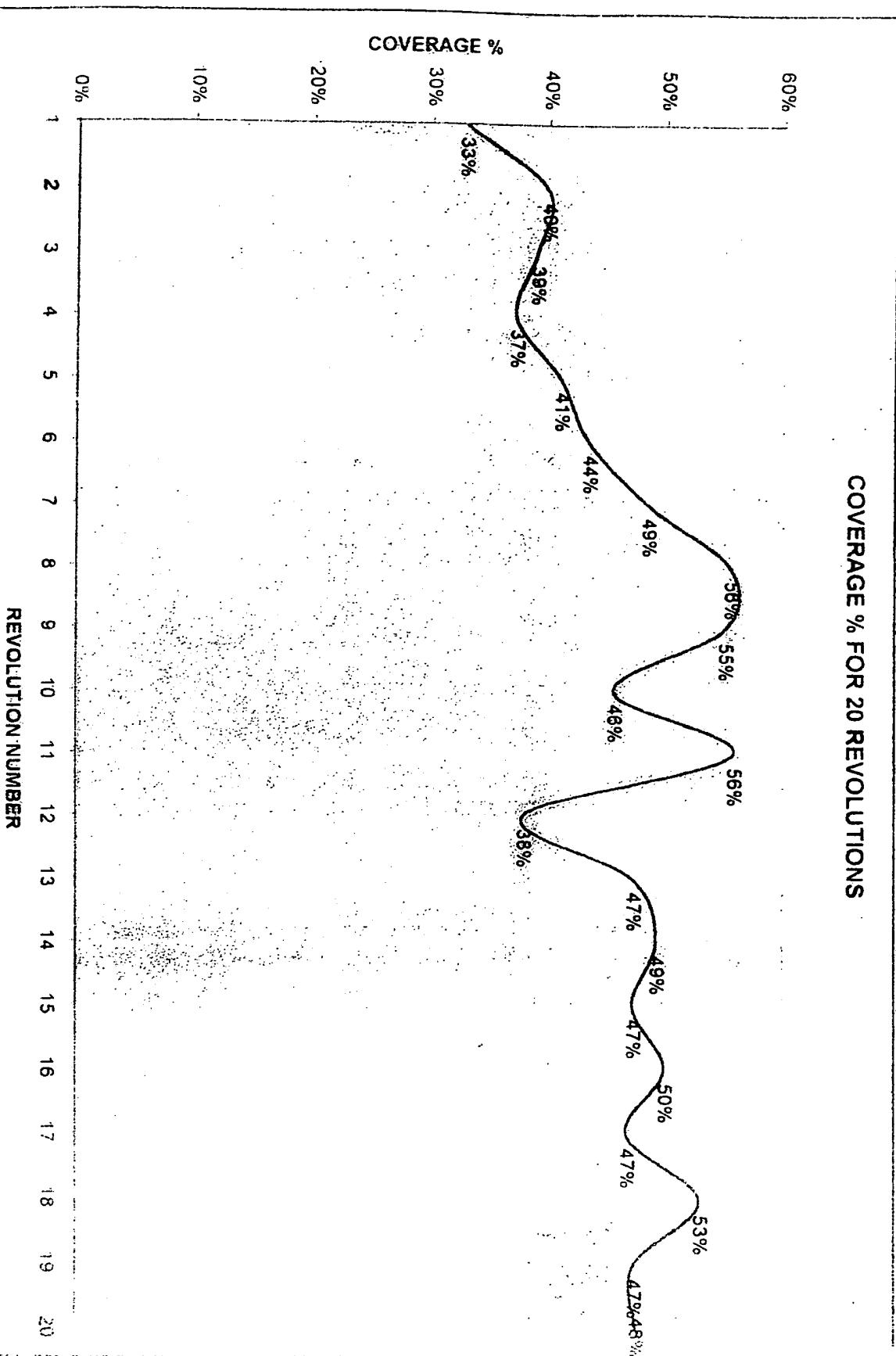


## PERFORMANCE OF F00 BIT IN MEDIUM DUCTILE ROCK

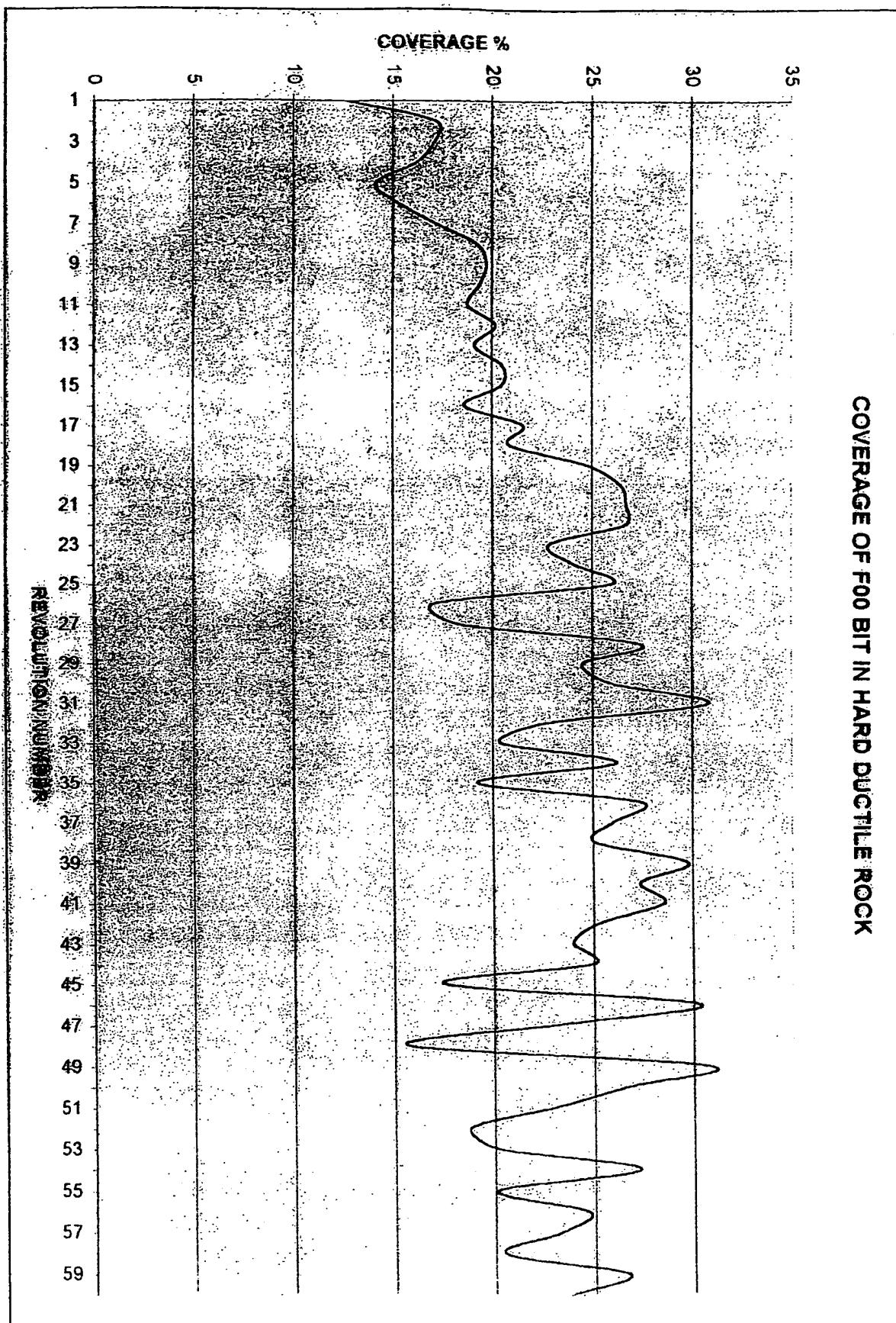
CONE1  $\times$  CONE2  $\star$  CONE3



### COVERAGE % FOR 20 REVOLUTIONS



COVERAGE OF F00 BIT IN HARD DUCTILE ROCK



Drilling Depth

100' BATTLE ROCK

600

10

20

30

40

50

60

70

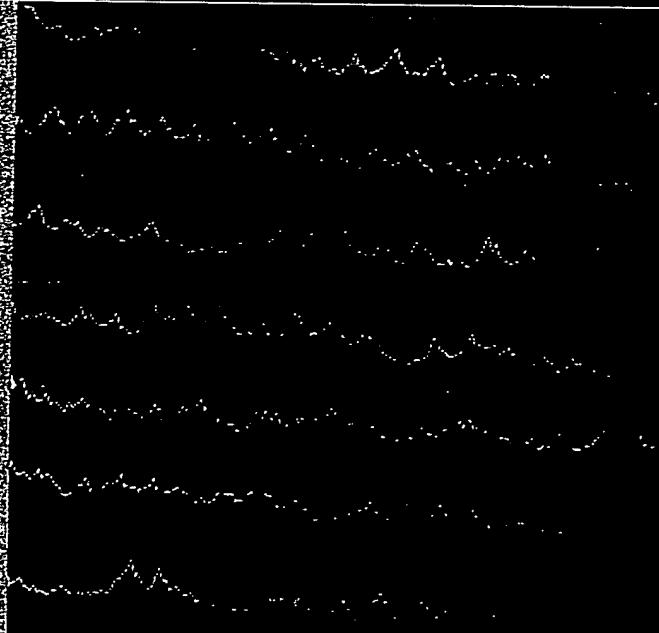
80

90

100

110

120



Drilling Depth

100' BATTLE ROCK

ROP: 0

0

1.0

2.0

3.0

4.0

5.0

6.0

7.0

8.0

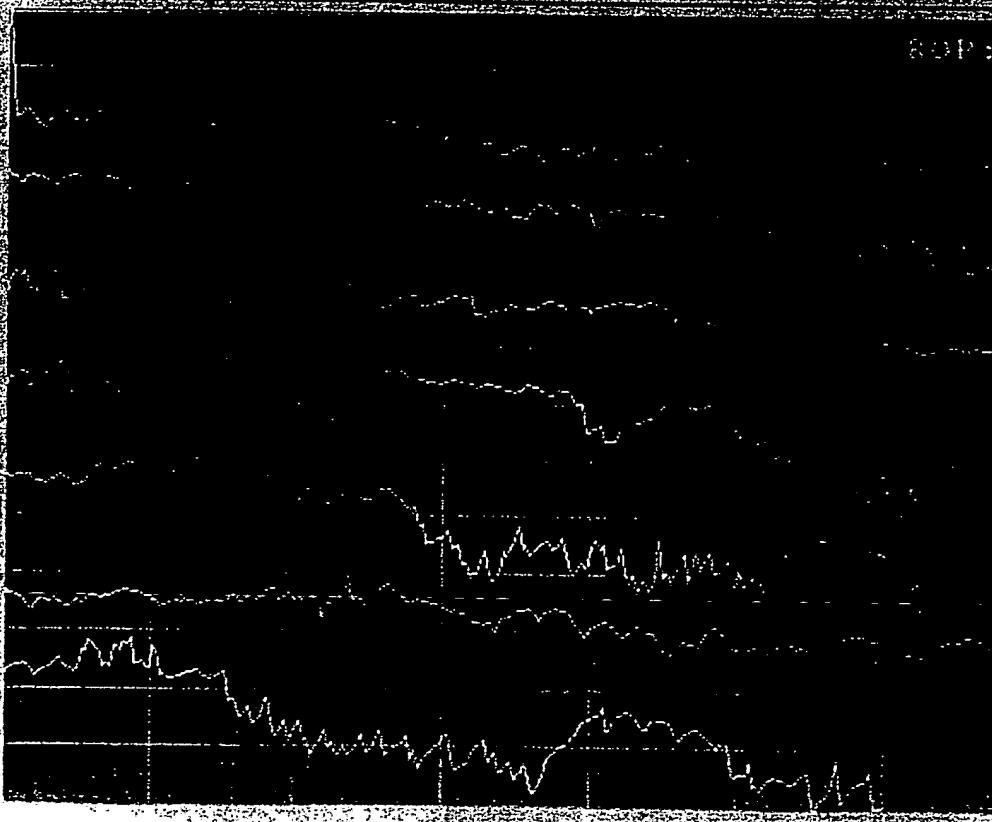
9.0

10.0

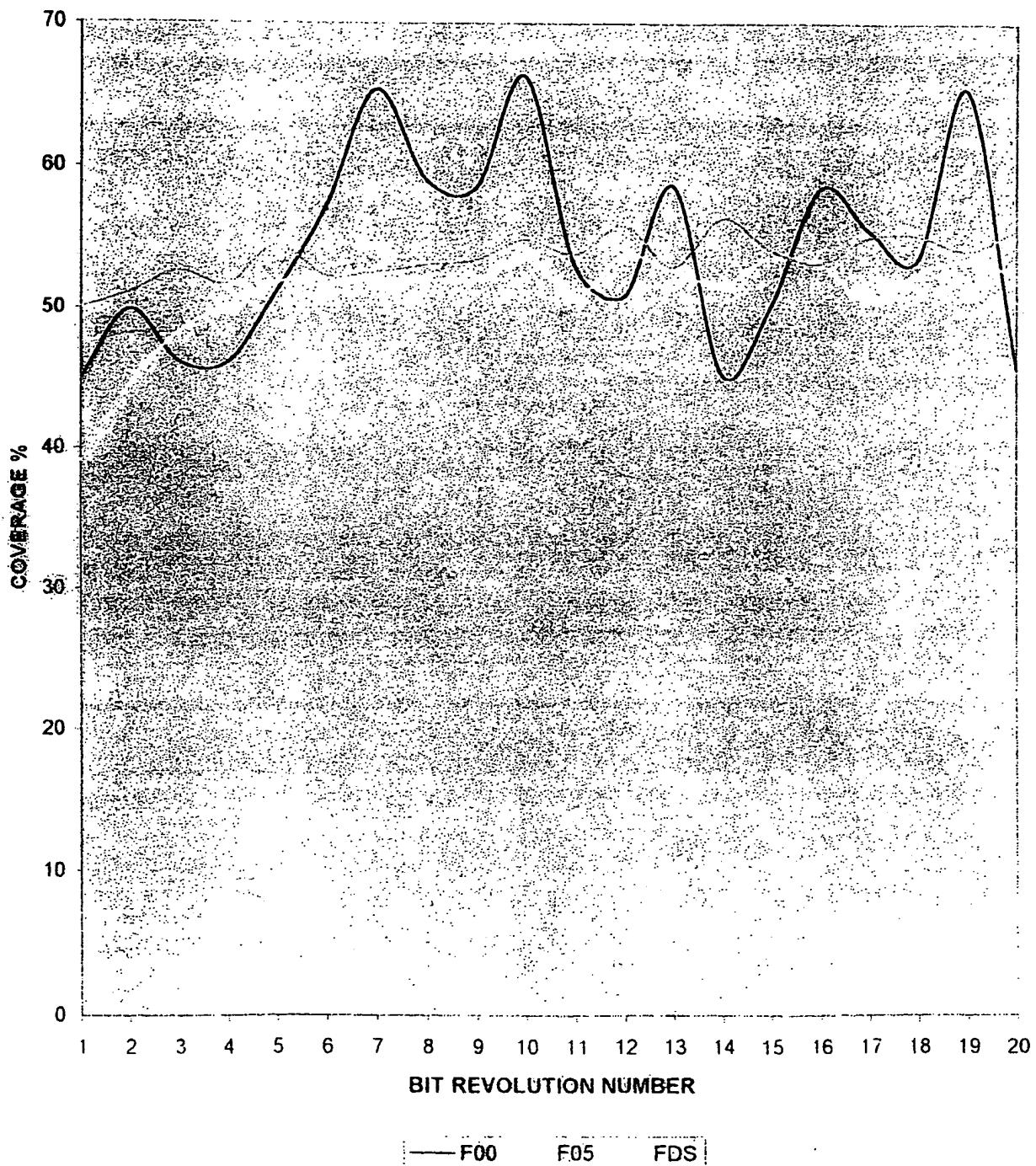
11.0

12.0

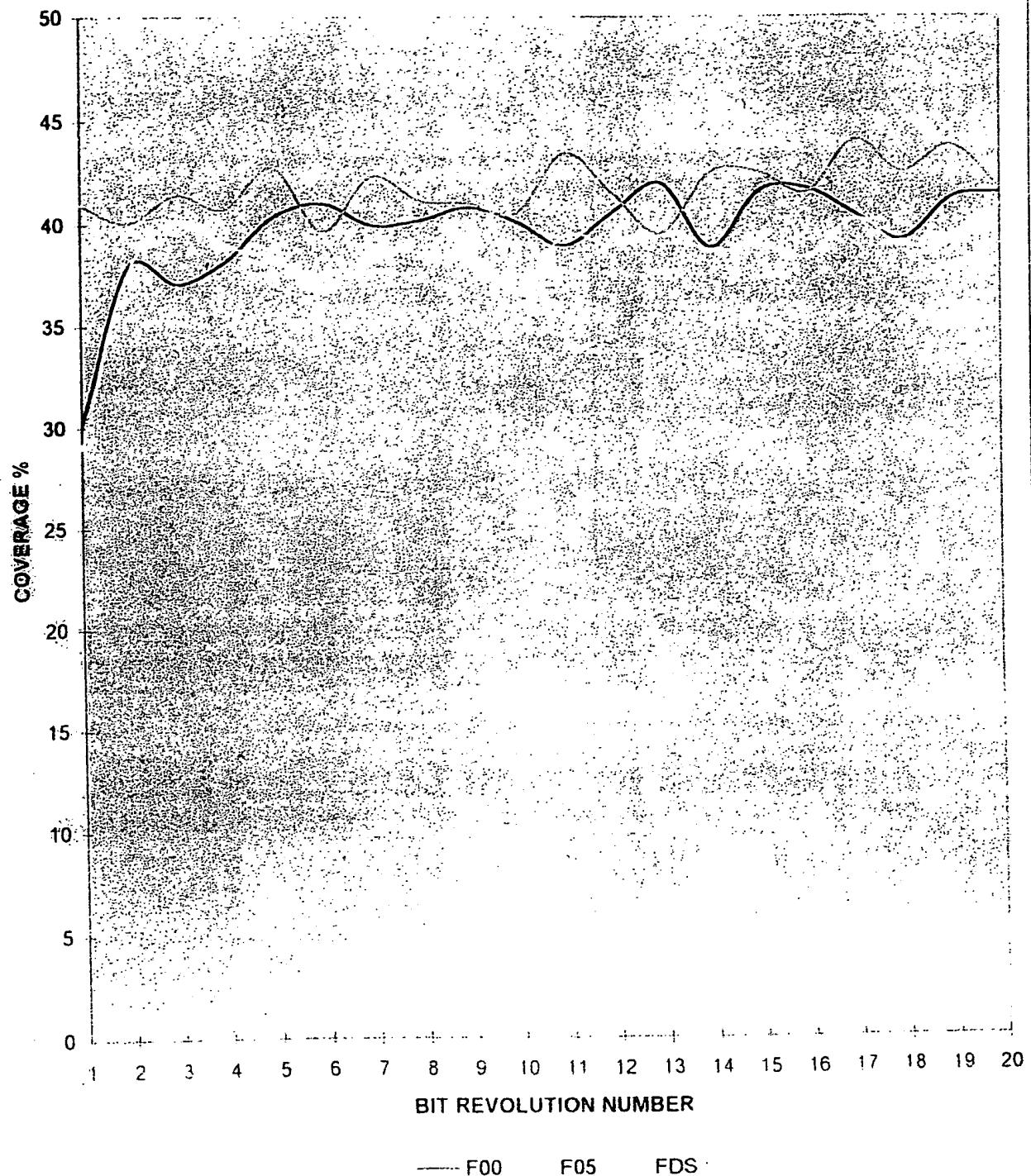
Command



**COVERAGE OF F00 BIT VERSUS THE F05 AND FDS BITS IN  
DUCTILE ROCK**



**COVERAGE OF F00 BIT VERSUS THE F05 AND FDS BITS IN  
BRITTLE ROCK**



**BIT TYPE: F90**  
**ROCK: BRITTLE**